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Putting Ideas to Work

THE criticism has often been levelled against this country, that whilst we are quick to invent, we are slow to apply new ideas, and that this tardiness is one of the principal factors affecting adversely our attempts to improve productivity. To obtain material for a recent series of television programmes with the general title of "Putting Ideas to Work," Charles Orr-Ewing has been travelling round the country investigating the truth or otherwise of the accusation. That it is not without foundation is generally accepted, and cases are known where ideas originating in this country have been developed as far as the production stage in other countries in advance of progress here. We have in the past been rather too complacent about this state of affairs: we have rather prided ourselves that we have provided the genius, and that others have merely built on our foundations. But whilst it is true that one must have an idea to work on, and that without a basic idea, no amount of hard work will get one anywhere, it is also true that an idea which remains an idea, without being put into practice, is equally useless. From a commercial point of view, too, speed of development is important if one is not to see competitors win the race for markets.

We do not, of course, really believe that we have a monopoly of ideas, any more than we accept the inference that we are incapable of translating our ideas into practical realities, although there is room for improvement in the development stage. Before an idea can be developed, however, there must first come the recognition that it is worthy of development, and that is where the importance of technological training arises, with its appreciation of the difficulties likely to be encountered in putting the idea to work. For the first recognition of the value of an idea, and for its subsequent development, technological training is required, and men with it constitute one of the most serious shortages at the present time: instead of firms interviewing a number of men and selecting one from them, the practice now is for a man to see a number of firms and take his choice. This position was stressed at the conclusion of the television survey referred to earlier, when the managing director of an aircraft company gave his views, and emphasized the need for increased recruiting to the ranks of scientists and technologists.

Lord Hives, managing director of Rolls Royce touched on this matter when he opened the new engineering laboratories at Nottingham University last year. He attributed the situation to the attitude of mind of the parents and of the schools, for there still survived the idea that a career in industry was not so respectable as one in the services or the professions. It is evident that some forceful propaganda is needed to convince parents and schoolmasters that industry can offer work that is not only interesting and absorbing, but also remunerative and of very great national value. It was rather disheartening to learn therefore, that although two one-week courses, arranged last summer by United Steel to show schoolboys and undergraduates the opportunities the steel industry has to offer, were filled to capacity, a similar course for schoolmasters had to be abandoned for lack of support. Just how is this enlightenment to be achieved? Articles and speeches by well-known figures may have some effect, but it is probable that a remark passed in conversation at the club, in the train, or over coffee may have far more influence. As in other circumstances the personal touch has much to recommend it.

Although there is a definite shortage of trained technologists, the situation may be made to appear to be less serious than it really is because many firms do not appreciate the help which science could give them and, in consequence, they consider that they can manage very well without it. Some interesting facts came to light during a study undertaken on behalf of the Manchester Joint Research Council. In a book "Science and Industry" recently published by the Manchester University Press, the results of a survey of a large number of firms representing the very varied industries in the Manchester area are presented. Of the firms studied, only half employed one or more trained technologists, although these firms represented more than 80% of the total employees covered by the investigation: four-fifths of the technologists were employed by slightly less than one third of the firms. There must, of course, be many concerns where the nature of the work does not call for scientific help, and in other cases the firm can rely on the material supplier for help in his particular application problem. Again, the research associations can be of assistance in this respect, although the basic object of such associations is the general advancement of the industry concerned and not "trouble-shooting" for individual firms. To quote from "Science and Industry"—"a large number of members of research associations show little realisation of the full extent of the scientific help and other services which their particular association can afford." This is surely indicative of the need for a scientific mind in the firms concerned, for, excellent as is the work of the liaison departments of the research associations in getting across to members the significance of new developments, a scientific mind at the reception end can make that work a good deal easier and more effective, particularly if its owner is in a position of senior responsibility.

For some reason or other, the technical man is regarded in some quarters as unfitted for a seat on the board of directors: he is all right with his test tubes and his microscope, but he cannot understand the intricacies of business. That is an error of judgment of the first magnitude—in almost any sphere, the analytical and dispassionate approach to a subject engendered by a scientific education, cannot but be helpful in reaching a sound conclusion. Fortunately, there is a growing

realisation, to the advantage of the firms concerned, that a technologist can make a useful director, and even a managing director. But until the view is more widely accepted that there is room at the top, what chance is there of an improvement in recruitment for industry?

Insignia Award in Technology

FROM time to time we have made reference to the new Insignia Award in Technology of the City and Guilds of London Institute. The first list of successful candidates for the Award has now been made. They are :—

A. A. DAULTREY (Production Engineering),

E. RYALLS (Welding Technology), and

T. HURST (Foundry Technology).

Actually some seven more candidates have since been reported on favourably from other fields of industry, both by their assessors and by the appropriate interviewing panels, and these are awaiting confirmation of award by the Executive Committee when it next meets.

In accordance with the Rule empowering the Institute to make one annual award to suitable recipients of distinction in respect of each of the five main industrial groups, the Council of the City and Guilds of London Institute has conferred the Insignia Award upon the following :—

DR. H. W. CLARKE (Chemical Industries—Metallurgy),

J. BATTY, A.R.I.B.A. (Constructional Industries—Architecture),

E. H. JOLLEY, M.I.E.E. (Electrical Industries—Telecommunications),

S. H. RUSSELL (Mechanical Industries—Foundry Engineering), and

T. R. BARLOW, A.T.I. (Textile Industries—Hosiery).

The regulations for the Award have been amended so that for an interim period candidates need not be refused registration because they hold no Full Technological Certificate or other City and Guilds certificate qualification, provided they are in possession of others that are deemed to be acceptable by the Committee.

Lead Development Association

UNDER the sponsorship of the leading Commonwealth producers of lead, the Lead Development Association has been formed as a non-profit-earning body. The objects of the Association are to extend the knowledge of lead in its manifold uses and to foster appreciation of its services to mankind. Hitherto, the only organisation of its kind in the country giving information on lead matters has been the Lead Industries Development Council which confined its activities to those connected with lead sheet and lead pipe. With the formation of the Lead Development Association the name Lead Industries Development Council will cease and its activities will continue as the Lead Sheet and Pipe Council, which becomes an associate member of the Lead Development Association. The offices of the Lead Development Association and those of the Lead Sheet and Pipe Council are at Eagle House, Jermyn Street, London, S.W.1. Telephone : WHItehall 4175.

Change of Address

S. A. WILD-BARFIELD have now moved to larger premises in Brussels, to be in a better position to handle an increasing volume of business. The new address is 62, Rue Ten Bosch, Brussels, Belgium, (telephone number : Brussels 47.38.82). There is no alteration to the telegraphic address, which remains Wilbarfild, Brussels. S. A. Wild -Barfield not only represent their parent company, Wild-Barfield Electric Furnaces, Ltd., but also G.W.B. Furnaces, Ltd., of Dudley, The Applied Heat Co., Ltd., of Watford, The Foster Instrument Co., Ltd., of Letchworth and Parkinson & Cowan, Ltd., of London. They are also agents and manufacturing licencees of Thermic Equipment & Engineering Co., Ltd., of Preston, whose gas and oil fired furnaces they make in Belgium.

May Diary

4th

Institute of Metals—Birmingham Local Section. Annual General Meeting and Chairman's Address. James Watt Memorial Institute, Great Charles Street, Birmingham. 6.30 p.m.

Society of Chemical Industry—Corrosion Group. Annual General Meeting, followed by a Discussion on "Corrosion and Design." By W. E. BALLARD, W. S. ATKINS AND E. BATESON. Chemical Society, Burlington House, Piccadilly, London, W.1. 6.30 p.m.

5th

Institution of Electrical Engineers, Scottish Centre. Annual General Meeting, S.W. Scotland Sub-Centre. Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2. 7 p.m.

6th

Leeds Metallurgical Society. Annual General Meeting and Films. Chemistry Department, The University, Leeds, 2. 7.15 p.m.

7th

Institute of Fuel—South Wales Section. Annual General Meeting and Chairman's Lecture. South Wales Institute of Engineers, Park Place, Cardiff. 6 p.m.

11th

Institution of Works Managers—Birmingham Branch. Annual General Meeting. Grand Hotel, Birmingham. 7 p.m.

12th

Institution of Engineering Inspection—West of Scotland Branch. Annual General Meeting. St. Enoch Hotel, Glasgow. 7.30 p.m.

13th

Institution of Engineering Inspection. Joint Meeting with the **Institute of Metal Finishing.** "Corrosion in Theory and Practice." By T. P. HOAR. The Engineers' Club, Albert Square, Manchester. 7.30 p.m.

18th

Institute of Metals—London Local Section. All-Day Visit to Ford Motor Co., Ltd., Dagenham.

26th–27th

Iron and Steel Institute. Annual General Meeting. Lecture Theatre, Royal Institution, Albemarle Street, London, W.1., and 4, Grosvenor Gardens, London, S.W.1.

26th

Iron and Steel Institute. Annual Dinner. Grosvenor House, Park Lane, London, W.1.

27th

Institute of Fuel—Midland Section. Annual General Meeting. James Watt Memorial Institute, Great Charles Street Birmingham, 3. 6 p.m.

Incorporated Plant Engineers (Sheffield and District Branch). "Industrial Refrigeration Problems." REFRIGERATION DIVISION OF PRESSED STEEL COMPANY, COWLEY, OXFORD. Grand Hotel, Sheffield. 7.30 p.m.

The Running and Feeding of Castings

Recent Scientific Studies of the Problems Involved

At a recent meeting of the Lancashire Branch of the Institute of British Foundrymen, Mr. R. W. Ruddle, Head of the Casting Section of the British Non-Ferrous Metals Research Association, delivered a lecture on the running and feeding of castings, based on a number of recent scientific studies of gating and feeding methods. A report of Mr. Ruddle's lecture is presented here.

THE production of serviceable castings is a complex matter, depending on the combination of a number of factors, two of the most important of which are the technique used to run the casting, and that employed to ensure that the casting is adequately sound. The penalties for using unsatisfactory techniques may be severe, leading to a variety of troubles, such as shrinkage unsoundness, dross, inclusions, trapped gases, mould and core erosion, and the various troubles which may follow in the wake of excessively high pouring temperatures. Harding[1] has stated that 30–50% of foundry rejections are the result of incorrect gating practice, and one might hazard a guess that foundry rejections resulting from incorrect feeding are often of the same order.

Until quite recently, the methods used to run and feed castings have been based on the collective experience of foundrymen over many years, and little attempt has been made scientifically to assess the value of the techniques commonly practised. However, in the last ten years or so a number of scientific studies have been made of both gating and feeding methods, and it is on these studies that the present lecture is based.

Gating and Feeding Requirements

Before proceeding to a discussion of these subjects in detail, an attempt will be made to define the features which technically ideal gating and feeding systems should possess. Taking gating first, an ideal system should :

(1) avoid the production of dross and its passage into the casting (it should also be capable of preventing dross or slag present in the ladle from passing into the casting) ;
(2) avoid the entrainment of air or mould gases in the metal stream ;
(3) avoid mould and core erosion ;
(4) avoid the necessity for excessively high pouring temperatures ;
(5) maximise the casting yield ; and, finally,
(6) introduce the molten metal into the mould cavity at rates and at locations such that solidification takes place in such a way as to minimise shrinkage unsoundness and distortion of the casting.

This last point leads to the ideal feeding system, which should :

ensure that the casting is of adequate soundness, without reducing the casting yield to a low figure.

The feeding system is considered to comprise the feeders, chills and gates attached to the casting.

In addition to the above requirements, the methods of gating and feeding chosen must be commercially practicable. Just what is meant by commercially practicable, of course, depends very much on the casting being made and the alloy in which it is made. Obviously, in the case of a highly-stressed casting for an aircraft, production economics will allow a closer approach to the ideal gating and feeding system than they would in the case of, for example, a doorknob. The gating and feeding technique, used with any casting will, therefore, be a compromise between quality and economy, and in general economic considerations will necessitate some relaxation of the ideal requirements. Furthermore, the necessity for ideality varies very much with the alloy being cast. For example, it is generally necessary to use more carefully designed gating systems with light alloys, than, say, with cast iron.

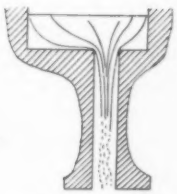


Fig. 1.—Flow in parallel sprues.

The Flow of Metals in Gating Systems

In considering the technical aspects of the flow of metals in gating systems, a start may be made with a sprue or down gate alone, attached only to a pouring basin (Fig. 1). The liquid metal falls through the hole in the pouring basin into the sprue, and as it travels down the sprue it accelerates under the influence of gravity. This acceleration has two consequences : first the metal stream acquires a high velocity in its passage down the sprue. The theoretical velocity thus acquired is given by the simple equation for $V^2 = 2gH$, and some idea of its magnitude can be gained from a few rough calculations. If the sprue is 6 in. high, the velocity of the metal at its base is about 68 in./sec., for a 12 in. high sprue it is 97 in./sec., and for an 18 in. high sprue, a velocity of 118 in./sec., or nearly 10ft./sec. would be attained. The second consequence of the acceleration of the metal is that the stream contracts as the velocity increases, and draws away from the walls of the sprue. This point will be referred to again later.

If now a cross runner and gate is attached to the sprue, the latter becomes partially filled with metal as pouring proceeds, as the result of the resistance to flow offered by the bends in the system, and of the runner wall friction. As has been shown by Pellini and co-workers[2] in the U.S.A., short sprues 6 in. high tend to fill completely, whereas long sprues are generally incompletely filled when the sprue/runner area ratio is 1/1. This is illustrated in Fig. 2. The precise sprue height at which incomplete filling begins is, of course, determined in a

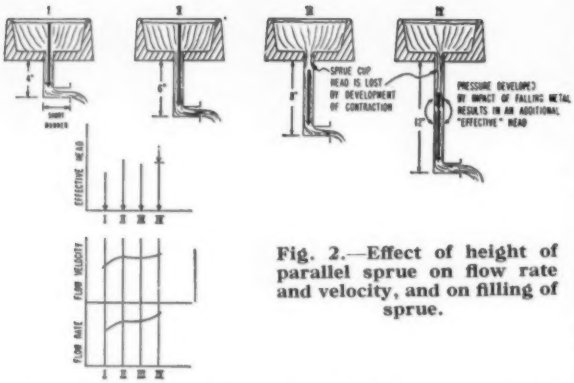


Fig. 2.—Effect of height of parallel sprue on flow rate and velocity, and on filling of sprue.

given instance by the amount of choke, i.e., by the geometry of the system. Unfilled sprues are undesirable, because the drawing away of the metal stream from the sprue walls, and the consequent agitation, permit oxidation of the metal to take place, and this may lead to the introduction of dross inclusions into the casting. Furthermore, unless the runner cross-sectional area is less than that of the sprue, the runner will also be incompletely filled, as is illustrated in Fig. 3, and this may again lead to the formation of dross. As Fig. 3. shows, filling is least complete near the sprue but (in the case of a long runner) as the stream proceeds down the runner, it expands as its velocity decreases, and eventually it completely fills the runner. If, on the other hand, a runner of small diameter is employed, the runner will be full, but the metal may enter the mould cavity with an undesirably high velocity. The velocity of the metal in the runner depends largely on the effective head in the sprue, i.e., on the extent to which the sprue is filled, and on the ratio of the cross-sectional areas of the runner and sprue. When the runner area is large, the sprue head is small and the velocity in the runner is low ; conversely when the runner is small the head is large. There is, therefore, a large head forcing metal through a restricted channel—with a resultant high runner velocity.

Reference was made earlier to another undesirable effect of unfilled sprues. Several groups of American workers[3,4] have shown that, if the sprue is incompletely filled, some degree of vacuum is formed in the incompletely filled parts and this causes aspiration of mould gases and further dross formation. Experimental work indicates that aspiration in parallel sprues can never be entirely eliminated. Separation of the metal stream from the walls of the ducts also tend to occur at sharp bends, particularly that at the base of the sprue, and here also aspiration of mould gases may occur. Research has shown that this aspiration may be minimised by rounding the bends.

Improved Gating Systems

As has been shown, many gating systems in common use are technically unsound, either because the metal enters the mould cavity at a high velocity, or because the runner is unfilled : in either case dross formation and other undesirable phenomena result. Furthermore, aspiration of mould gases may occur at certain points and this also leads to dross formation and gas entrapment in the casting. An additional objection is that flow is generally highly agitated, and this causes rupturing of the oxide skin on the stream of metal, with the result that, in the case of those alloys which form tenacious oxide skins, fragments of these skins are led away in the stream into the casting. The problem in designing a technically ideal system is, therefore, (*i*) to reduce the velocity of entry into the mould cavity to a low value (Eastwood[5] has stated that, in general, this velocity should be $\frac{1}{8}$ of that at the base of the sprue) ; and (*ii*) to see that the system is completely filled throughout, so that aspiration and rupturing of the oxide skin do not occur. If this is done, dross formation will clearly be minimised.

How then can these ends be attained? Recent American work suggests several ways. For example, Eastwood and his colleagues have designed a gating system in which aspiration, etc., is avoided by careful streamlining of the system, and the velocity is reduced by making the runner and gate areas six times that of the sprue exit area, (Fig. 4). It will be noted that this system features a pouring basin, a tapered sprue, an enlargement at the sprue base, and gates taken off the top of the runner. The reason for employing a tapered sprue is that the taper compensates for the contraction of the metal stream as it proceeds downwards, and thus prevents separation from the sprue walls and consequent aspiration of mould gas. The gates in this system are taken off the top of the runner so as to ensure complete filling of the latter.

Another good way of reducing the velocity with which the metal enters the mould is to employ slot sprues. If a large volume of flow is required, multiple slots may be used. Velocities in slot sprues are much lower than in the usual round-sectioned sprues, on account of the higher frictional resistance. A further possibly useful way of reducing the velocity of flow, and at the same time ensuring filling of the sprue, is to insert screens or strainer cores in the runner or sprue base. Fig. 5., taken from a paper by Tedds, suggests good and bad ways of doing this. A possible objection to this method is that severe agitation and dross formation may occur in the region following the core or screen.

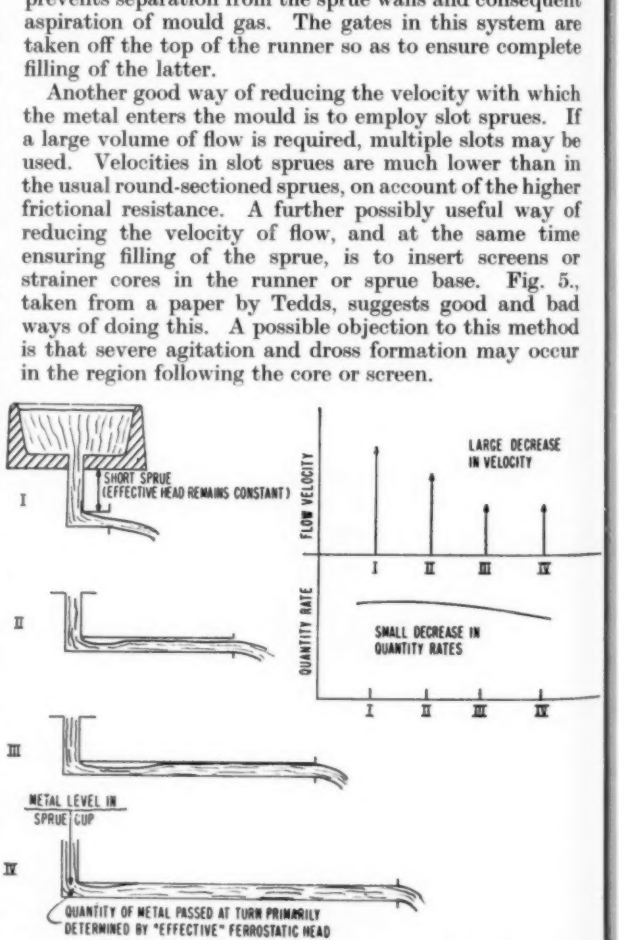


Fig. 3.—Effect of runner length on velocity and rate of flow in gating systems embodying parallel sprues. The diagram also shows that long runners tend to be completely full whereas short runners are only partly full.

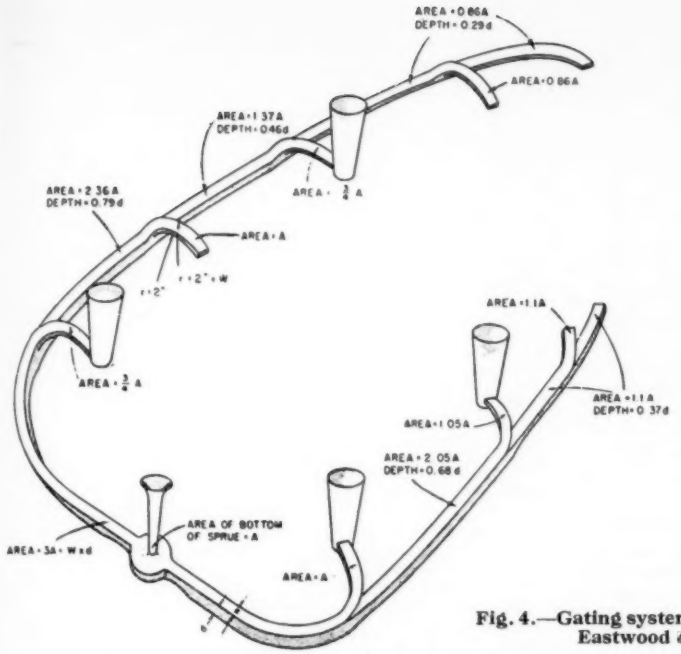
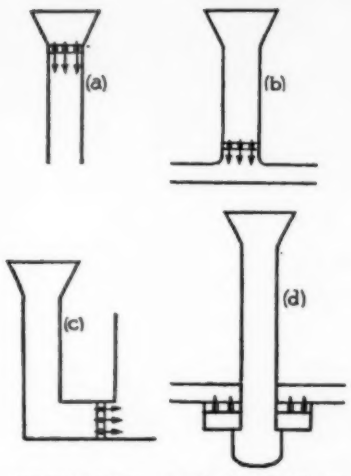


Fig. 4.—Gating system designed by Eastwood *et al.*



Freedom from Dross	Freedom from Turbulence
(a) Fair	(a) Poor
(b) Good	(b) Fair
(c) Good	(c) Good
(d) Good	(d) Excellent

Fig. 5.—Diagram illustrating use of strainer cores.

Straightforward multiple gating systems, in which the sprue is attached to one end or to the centre of the runner bar and all the different channels have the same cross-sectional area, are unsatisfactory, since the metal flows straight to the end of the runner bar as a result of its momentum, and then out through the end gates. The gates nearer to the sprue do little or no work. Researches carried out by Pellini and his colleagues in America have indicated three ways in which this trouble may be overcome. In one technique, sharp bends are introduced into the runner so that the momentum of the metal is largely destroyed; these systems are rather tricky to design. In the second method, the runner bar is greatly enlarged and sunk below the level of the gate. In a third method, the sum of the gate areas is made about half the total runner area, the gating ratio thus being 1 : 2 : 1. This method possibly results in rather high velocities of entry into the casting. The fourth method, that used by Eastwood and shown in Fig. 4., depends on careful proportioning of all the cross-sectional areas so that equal flow is obtained. This method may be too difficult for extensive commercial application.

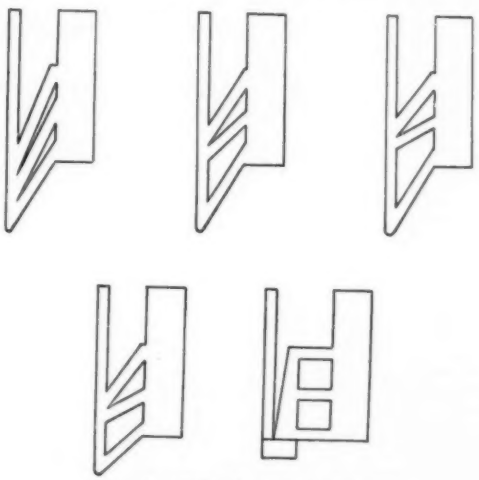


Fig. 6.—Effective step gates

On the question of step gates, Pellini *et al*[7] showed that all simple systems such as that in which three or four horizontal gates lead off a vertical down gate are entirely unsatisfactory, since most of the metal enters the casting via the bottom gate. In some cases, metal even runs back into the down gate through the upper gates when the casting is half full. Pellini *et al* tried many forms of step gate, but the only ones found to work satisfactorily are those shown diagrammatically in Fig. 6. Pellini states that the technique employing a tapered sprue is difficult to use because the amount of taper is very critical.

Elliott and Metzoff[8] have shown that side slot gates do not function as commonly supposed, but in a rather unsatisfactory manner, as illustrated in Fig. 7. These workers, therefore, designed the system shown in Fig. 8., which seems a great improvement on the conventional type of gate. Elliott and Metzoff are also inclined to the view that web gates are unsatisfactory in action, (Fig. 9.) partial freezing causing channelling and, consequently, leading to hot spots in the casting. Web gates are quite extensively used, particularly with light alloys, and the author has frequently seen evidence that they may be unsatisfactory.

As was stated earlier, the trouble justified in designing the gating system depends on the standard of quality required in the casting, and, in particular, on the type of alloy being cast. Practical foundrymen are aware of this point, but so far relatively little attention has been given to it by research workers, and just how far one can safely depart from an ideal gating system is by no means clear as yet. Mention should be made, however, of some experiments carried out by Pellini and his colleagues,[9] in which they cast plates in steel, cast iron,

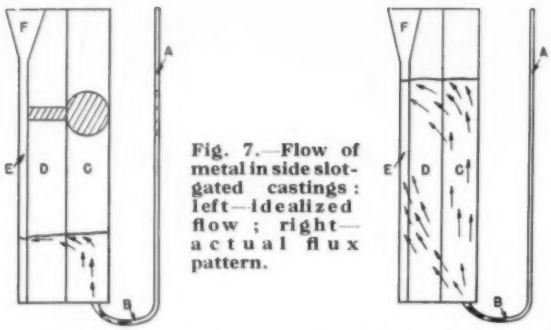


Fig. 7.—Flow of metal in side slot-gated castings: left—idealized flow; right—actual flux pattern.

high tensile brass and an aluminium alloy, using multiple gating systems in which uniformity of flow was obtained in two ways: (1) by using a gating ratio of 1 : 2 : 1, thus choking the gates; and (2) by minimising the momentum effects, either by the use of sharp bends or by enlargement runners; previous mention has been made of all these types of systems. They discovered that satisfactory castings could be made in steel and cast iron with more or less any gating system, but that in the case of aluminium alloys and high tensile brass, the best results were given by the first method, namely the use of mildly choked gating systems. They attribute this to the fact that in such systems the channels are always completely full of metal, whereas in the case of the other methods the channels are only partially full, and opportunity for dross formation exists. The inference which Pellini *et al* tentatively draw from this work is that considerable liberties may be taken with the gating system in making iron and steel castings, and that much more care must be exercised in designing gating systems for alloys such as light alloys and manganese and aluminium bronze, which readily form tenacious oxide skins. The position in this respect of the brasses and bronzes is, as yet, not clear.

General Principles of Feeding

Two types of shrinkage cavity occur in castings: on the one hand, shrinkage may occur in the form of pipes and large cavities, and on the other, it may manifest itself as widely dispersed micro-porosity. The mode of solidification of the alloy governs which of these two kinds of porosity will be found in a casting. In general, alloys solidify in two ways[10]. The pure metals and many alloys of short freezing range solidify by what is known as skin formation. As the name implies, solidification begins at the walls of the casting and progresses inwards, a shell or skin of completely solid metal being built up on the outside of the casting, the centre of which is entirely liquid. The second group of alloys, namely those of long freezing range, freeze in an entirely different manner. Solidification begins at the mould walls as before, but the initiation of crystallization rapidly extends right to the centre of the casting. As a result, throughout the greater part of the solidification period these castings consist of a mush of liquid in which solid-crystals are growing. This kind of solidification has been termed pasty solidification, and it is not hard to see why it leads to the formation of dispersed micro-porosity since all parts of the casting are competing for feeding liquid at the same time.

There are two ways of dealing with shrinkage. In the first place one can seek to eliminate it entirely: this is usually essential with the skin-forming type of alloy, for unless the shrinkage is entirely eliminated quite large cavities will be present in the casting. Elimination is effected by positioning the feeders, gates and, if necessary, chills in such a way that solidification begins in the thinnest parts of the casting and the solidification front, or fronts, progress towards the heavier sections. The heavy sections should have feeders attached to them and the gates should lead into the heavy section. Thus, the thinner sections of the casting solidify first, followed by the intermediate sections and then by the heavy sections, and, last of all, solidification is completed in the feeder. If this technique, which is called directional solidification, is carried out properly, all the shrinkage cavities are confined to the feeder and the casting itself is sound.

Directional solidification may also be applied to alloys which solidify by pasty solidification, but even if freezing is fully directional it is usually not possible entirely to eliminate micro-porosity from sand castings in these alloys. A certain amount of residual micro-porosity is, therefore, almost inevitable with long freezing range alloys. Now a moderate amount of micro-porosity does not greatly harm the properties of the casting, provided it is well distributed and not concentrated in the heat centres of the casting, and provided it is not of an interconnecting type which is likely to lead to leakage on pressure tests. With these alloys, therefore, an alternative to the method of directional solidification is to tolerate a moderate amount of micro-porosity and to ensure that it is distributed as evenly as possible throughout the casting.

The technique adopted in this case is the opposite of directional solidification. In the latter, the aim is to produce steep temperature gradients in the direction of the feeders; whereas to avoid concentration of micro-porosity the temperature gradients should be as flat as possible, so as to ensure even solidification throughout the casting.

Hence, instead of chilling the thin sections and gating into the heavy sections to which feeders are attached, the technique used is to gate at a large number of points, especially into the thin sections, to make the casting solidify uniformly; the use of feeders is minimised. Of course, in the case of many complex castings, it is exceedingly difficult to ensure that solidification occurs in a uniform manner, and, if local shrinks or depressions

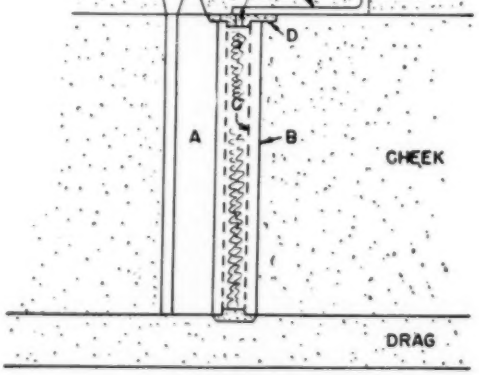


Fig. 8.—Improved side slot-gate designed by Elliott and Metzoff.

TABLE I.—COMPARATIVE FREEZING TIMES OF SIMPLE SHAPES OF EQUAL VOLUME

Feeder Shape and Size	Volume (cu. in.)	Area (sq. in.)	Solidification Time (min.)
Sphere: 6 in. dia.	113	100	7·2
Cylinder: 8 × 4½ in. dia. ..	113	120	4·7
Square: 3⅝ × 3⅝ × 3⅝ in. ..	113	135	3·6
Plate: 2½ × 6¼ × 8in.	113	160	2·7
Plate: 1$\frac{23}{64}$ × 10$\frac{5}{32}$ × 8 in. ..	113	220	1·5

of the surface are found here and there, it may be necessary to attach small feeders near these points in order to give a little local feed. It is sometimes possible to treat small local concentrations of internal porosity in a similar manner; alternatively chills may be used. It will thus be seen that the method of feeding adopted governs the location of the gates; with directional solidification relatively few gates should be used and they should be situated close to the feeders. On the other hand, when uniform solidification is practised a large number of gates are desirable, arranged in such a manner as to even out the temperature gradient in the casting.

Feeder Size and Shape

An important point in feeding is the shape of the feeder. For directional solidification to occur, the feeder should remain molten longer than any part of the casting, and it is, therefore, desirable that its shape should minimise the loss of heat from it and thus increase its solidification time to the maximum possible for a given volume of metal. Table I shows the freezing times of some simple shapes of the same volume[11], from which it can be seen that a sphere is the ideal form of feeder. This, unfortunately, is not very practical, and resort must normally be made to the next best design, which is a cylinder. In the case of alloys solidifying by skin formation, it is usually desirable to make the length of the cylinder equal to one and a half times the diameter, so that the pipe does not penetrate into the casting.

Some progress has been made in recent years towards the calculation of feeder size. According to Chvorinov[12] the freezing time of a mass of metal is proportional to the square of the ratio of its volume to its area. This rule is only approximate, but is a useful one for the calculation of feeder sizes. If the ratio is calculated for the casting,

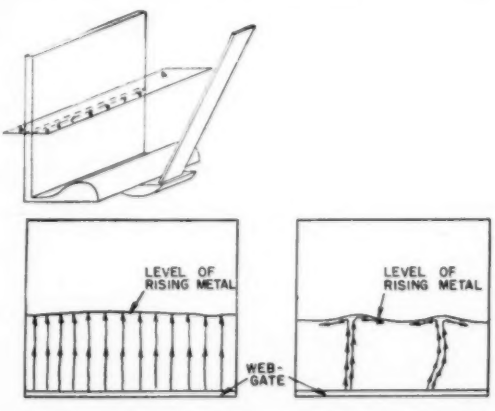


Fig. 9.—Flow of metal in bottom web-gated castings: (a) sketch of casting (upper diagram); (b) idealized flow (bottom left diagram); (c) actual flow pattern (bottom right diagram).

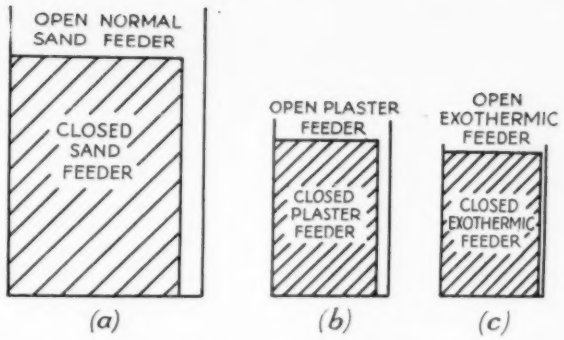


Fig. 10.—Diagram showing relative sizes (efficiencies) of various kinds of feeder whose solidification times are the same: (a) sand-moulded feeders; (b) plaster-sleeved feeders; (c) feeders sleeved in exothermic material.

then the correct size of feeder will be one whose ratio is about twenty to fifty per cent greater than that of the casting. It must be emphasized that this use of the rule is rather rough and ready and the matter is really considerably more complex. Caine[13], using Chvorinov's rule and reasoning too detailed to go into here, has carried the matter a little further, and has given a curve for determining the minimum size of feeder which will render sound a steel sand casting of given size and volume/area ratio. The recent work of Pellini *et al* is of great interest in connection with feeding. These workers have examined in considerable detail the areas which a feeder of a given size will feed, and have dealt with castings of various typical shapes, bars, plates, discs, etc. Unfortunately, space precludes detailed discussion of this work, and the original papers should be consulted for further information.

Improved Feeders

Certain techniques have been advanced in the last few years for improving the efficiency of feeders, namely, the use of plaster insulating and exothermic feeder sleeves. These sleeves, on account of their insulating and/or exothermic effects, greatly retard the solidification of the feeder, thus increasing its efficiency. Normal sand moulded feeders can thus be replaced by sleeved feeders of much smaller volume, as shown diagrammatically in Fig. 10. As this figure indicates, exothermic sleeves are rather more efficient than plaster sleeves; however, the latter have the advantage of being cheaper. Use of either type of sleeve with all but small castings results in a substantial increase in casting yield, and this economy alone may justify the cost of the sleeves. However, in addition, valuable further economies arise from the reduction in fettling costs consequent on the use of these sleeves, especially with castings in hard alloys such as aluminium bronze. Plaster sleeves may incorporate Washburn cores, which, of course, still further reduces fettling costs. There seems little doubt that these new feeding techniques have a most useful field of application in foundry technology.

Chilling

Chills are often regarded as being somewhat dangerous things. This belief has probably arisen because chilling is never practised in a quantitative way and it seems that, unless chilling is so dealt with, trouble will inevitably

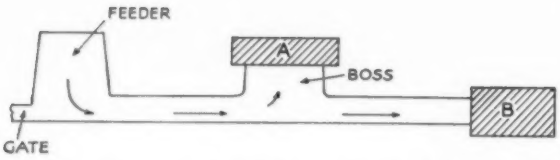


Fig. 11.—Diagram illustrating method of chilling plate casting with attached boss. A—chill used to eliminate effect of boss. B—chill used to improve directional solidification. Arrows indicate direction of heat flow.

be encountered from time to time. Now a chill acts in the following way: as soon as the molten metal comes in contact with it, it extracts heat extremely rapidly for a given time, namely until the temperature of the chill has risen to a high value approaching that of the casting. Then the rate of heat extraction rapidly decreases to a value equivalent to that of sand. Thus a chill causes a certain amount of metal to freeze extremely rapidly, and thereafter has a negligible effect on the progress of solidification of the rest of the casting. As a rough and ready rule, it may be said that a chill causes rapid freezing of a thickness of metal which is about equal to the thickness of the chill, but this, it must be emphasised, is very rough and ready, and the precise thickness depends upon the material of the chill and the alloy being cast.

The dangers of chilling can be simply illustrated by a casting consisting of a boss attached to a plate. This casting will normally contain shrinkage at the junction of the plate and the boss. Too thin a chill does not solidify enough metal and shrinkage is not eliminated. On the other hand, too thick a chill solidifies too much metal, bridging occurs across the section, directional solidification is impeded, and shrinkage appears. Clearly, the chill thickness must be just right for the job in hand. However, chills used in such a way that they abstract heat in the general direction of solidification (i.e. in the direction of the arrow Fig. 11.) can do little harm whatever their thickness.

A point which has been little examined so far is that it seems probable that chills can be of particular value with certain long freezing range alloys when it is desired to make castings of the highest possible soundness. As mentioned earlier, it is rarely possible to eliminate porosity entirely from these alloys when they are sand cast. However, the residual porosity decreases as the rate of freezing increases so that chills can be used to increase the overall rate of solidification of the casting and thus obtain castings of higher soundness than is normally the case.

Acknowledgments

We are indebted to the American Foundrymen's Society for permission to reproduce the illustrations used for Figs. 2, 3, 4, 7, 8 and 9, and to the Editor of *Foundry Trade Journal* in respect of Fig. 5.

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Dollar Order for British Shipyard

VICKERS-ARMSTRONGS, LTD. announce that they have received an order from Canadian Pacific Steamships, Ltd. for a 22,500-ton passenger and cargo liner, which will be built at their shipyard at Walker near Newcastle-upon-Tyne. The new liner will cost more than 15 million dollars, and is one of the largest dollar orders to be received by a British company in recent years. The machinery, which will consist of D.R. geared turbines to be built at Vickers-Armstrongs, Barrow, has been designed to develop a maximum of 30,000 shaft horse-power, giving a service speed of 21 knots. It is stated that the new ship is a sister ship to one already under construction at Fairfields on the Clyde, which will be named *Empress of Britain*. The name for the second vessel has not yet been chosen.

Die-Casting Specialists Visit U.S.

PLANTS specialising in zinc and light metal die-casting in many parts of the United States are being visited by a team of European experts which arrived in New York on March 30th aboard the *Ile de France*. The team comprises 34 specialists from twelve European countries, and their visit has been arranged under the O.E.E.C. Technical Assistance programme in agreement with the United States Foreign Operations Administration. The tour has been organised as a result of a proposal discussed by the European Pressure Die-Casting Committee set up last year by technical associations and principal firms in member countries to forward the interests of the industry. The application of American mass production methods, which are very highly developed in this field, would be of great benefit to European productivity in many branches of industry. On conclusion of their six-weeks' visit to the United States, the team will prepare a report for publication by the O.E.E.C.; this report will form the basis of a Conference to be organised by the Committee in the United Kingdom during October.

Federation of Light Metal Smelters

THE Federation of Light Metal Smelters announces that at the Ninth Annual General Meeting of Members held on 18th March, 1954, Mr. O. G. Halliwell (J. Frankel (Aluminium), Ltd.) was appointed Chairman for the ensuing year in succession to Mr. F. Farenden (The Eyre Smelting Co., Ltd.). Mr. O. Metzger (Enfield Rolling Mills (Aluminium), Ltd.) was appointed Vice-Chairman. The Members of the Council, in addition to the Chairman, Vice-Chairman and Mr. Farenden, are Mr. B. Endlar (John Dale, Ltd.), Mr. Rudolf Hahn (B.K.L. Alloys, Ltd.), Dr. Julius Jakobi (International Alloys, Ltd.), and Mr. R. T. Priestman (T. J. Priestman, Ltd.).

Change of Name

BRITISH ELECTRO METALLURGICAL CO., LTD., has changed its name to Union Carbide, Ltd. The business of manufacturers and suppliers of ferro alloys carried on by the Company will henceforth be carried on under the name of British Electro-Metallurgical Co., A Division of Union Carbide, Ltd.

The Efficiency of Some Protective Treatments in Preventing the Oxidation of Mild Steel at High Temperatures

By A. H. Sully, Ph.D., M.Sc., F.Inst.P., F.I.M.,
E. A. Brandes, B.Sc., A.R.C.S., F.I.M., and R. H. Brown, A.M.I.B.F.
Fulmer Research Institute

For many purposes, mild steel can be used at elevated temperatures, provided that oxidation can be prevented. In this paper, the authors present the results of an investigation into the relative effectiveness of chromising, aluminium coating and enamelling in providing protection against oxidation when the steel is heated to 700° C. for 1,000 hours. Shorter exposures at 800 and 900° C. are also discussed.

MILD steel can be protected against oxidation in air at high temperatures in a variety of ways. Impregnation of the surface with a metal of high intrinsic resistance to oxidation, such as aluminium or chromium, is a well known method. With chromium, impregnation is usually carried out by a vapour-phase reaction (chromising) but impregnation with aluminium may be effected by dipping, spraying, cementation, or vapour-phase deposition. In addition to these methods, refractory vitreous enamels have recently been developed which are claimed to be very effective in preventing oxidation of the underlying steel. The object of the present work was to assess the merits of the various enamels and protective metal coatings on the basis of comparative tests carried out under identical conditions. This paper describes the results of such a series of tests, the coatings being compared on the basis of an exposure of a period of up to 1,000 hours at a temperature of 700° C. and shorter exposures at temperatures of 800 and 900° C.

Materials for Test

With the exception of coatings J, K, L, M, N and O the coatings were supplied by manufacturers and were applied to mild steel specimens supplied by the investigators, but it was sometimes necessary to cut test pieces from larger specimens, so that such specimens were tested with exposed edges : these exceptions are noted.

The materials tested comprised the following :—

A, B.
Samples surface-impregnated with chromium by vapour phase treatment (chromised). *B* had unprotected edges.

C, D, E, F, G, H, I.
Samples coated with commercial protective enamels.

J, K, L.
Samples coated with protective enamels formulated and applied by the investigators.

M, N, O.
Samples coated with enamels corresponding to U.S. National Bureau of Standards Coatings A.417, A.19H and N.B.S. Enamel Frit 331 applied by the investigators.

P, Q.
Samples sprayed with aluminium and heat treated (specification D.T.D.907).

R.
Samples sprayed with aluminium but not heat treated (specification D.T.D.906).

S.
As *R* but sealed with ethyl silicate.

T.
Samples coated with aluminium by cementation.

U, V.
Samples coated with aluminium by dipping. *V* had unprotected edges.

W.
Samples coated with aluminium-silicon alloy (2·65% silicon) by dipping. Unprotected edges.

X.
Samples coated with aluminium by dipping and rolling. Unprotected edges.

Method of Test

The test piece consisted of a small coupon, $1\frac{1}{2} \times \frac{3}{4} \times 0{\cdot}036$ in., provided with a hook of 80/20 nickel-chromium alloy welded to the middle of one of the long edges. This assisted its manipulation during the application of the coating, and was also used for suspending it on a nickel-chromium alloy wire framework for the oxidation test. Any loose scale which dropped from the specimen was caught in a weighed porcelain crucible, and then weighed with the specimen at frequent intervals up to 1,000 hours. The increase in weight per unit area of the specimen was plotted against the time of exposure.

The specimens were heated inside an electric muffle furnace controlled to within ±10° C. with a stream of air passing continuously through it, at a rate of 2 litres/minute. In general, the thickness of the coatings supplied for test was not measured. The coatings applied by the investigators were, however, of controlled thickness : they were applied by spraying and were approximately 0·002 in. thick.

Results of Oxidation Tests

In assessing the results of these tests, it is important to compare the results with those obtained for unprotected mild steel. This is rapidly oxidised at 700° C. and the increase in weight is so large that its oxidation-time curve cannot readily be included on the graphs for comparison with those of protected samples. The oxidation curves for mild steel and for a steel containing 0·3% titanium, which has been considered as a base for enamelling, are shown in Fig. 1 : the titanium steel was tested in both the hot rolled and cold rolled conditions. Mild steel showed an increase in weight of about 28 mg./sq.cm. after 50 hours at 700°C. and 40 mg./sq.cm. after 100 hours. The titanium steel showed less oxidation in the initial stages of the test, but after 50 hours all three samples were oxidising at about the same rate, and at the end of 1,000 hours there was no significant difference between the three materials.

The oxidation-time curves for the chromised and the various aluminium-coated specimens are shown in Fig. 2, and for the various enamel coatings in Fig. 3. The

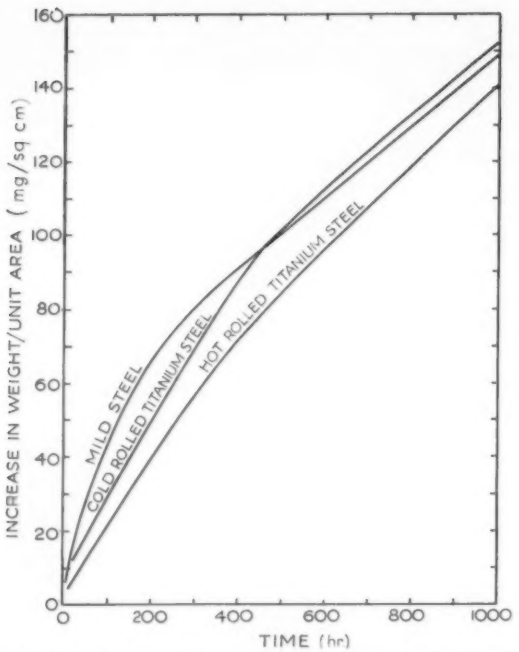

Fig. 1.—Oxidation curves of mild steel and steel containing 0·3% titanium at 700° C.

results are also summarised in Table I for tests at 700° C., and in Table II for short term tests on a few of the enamel coatings at 800° C. and 900° C.

Discussion of Results of Oxidation Tests

Chromised and Aluminium Coated Specimens.

All the coatings produced a marked improvement in the resistance to oxidation when compared with unprotected mild steel. The chromised coatings were outstandingly good. Sample *A* showed a negligible change in weight after 1,000 hours at 700° C. and, although sample *B* showed a small weight gain of 0·69 mg./sq.cm. in 100 hours, and 1·54 mg./sq.cm. in 1,000 hours, this is probably to be attributed to the fact that this specimen was tested with unprotected edges, and does not infer any real difference in quality between the two samples. These results confirm the work of Galmiche[1], who found that chromised coatings on steel had excellent resistance to oxidation at temperatures up to 900–950° C. at which temperature the oxidation resistance was decreased, due to a reduction of the surface chromium content resulting from interdiffusion between the chromium-rich surface layer and the underlying iron.

The specimens whose surface was protected by aluminium showed a considerable variation in their resistance to oxidation, although all gave an effective measure of protection to the underlying steel. Comparison between the various samples is difficult to make, because the thickness of the coating varied considerably between specimens treated in different ways. It would be unwise, therefore, to conclude from these tests that any one method is markedly better than another. Comparisons of this kind could only be made if specimens were prepared in a standard way and had a constant coating thickness.

The samples which were aluminium-sprayed (*R*), and aluminium-sprayed and sealed with ethyl silicate (*S*), attained a linear but fairly rapid rate of oxidation after about 300 hours, and were less protective than the other aluminium coatings. It is possible that this may be due to porosity in the sprayed coating. A sample which was aluminium-coated by cementation (*T*) also oxidised at a fairly rapid rate, as did the samples with a rolled-on aluminium layer (*X*) and a sample dip-coated with aluminium-silicon alloy containing 2·65% silicon (*W*): both the latter had unprotected edges. There was a considerable difference between two aluminium-sprayed and heat-treated samples, one (*P*) having an appreciably thicker coating than the other (*Q*). The first set of samples was treated according to specification DTD.907; and the second set was given the same heat treatment (5–20 minutes at 800° C.). but the thickness of the aluminium layer initially sprayed on was less than that demanded by the specification. The appearance of the two coatings, both before and after oxidation was different. The former was matte grey before and white after, whilst the smooth reddish-brown appearance of the latter remained practically unchanged during the test.

The aluminium-dipped samples had a high degree of resistance to oxidation, and were comparable with the better aluminised samples. Sample *U*, in particular, was extremely good, and its gain in weight was only 2·2 mg./sq.cm. after 1,000 hours at 700° C. It should

TABLE I.—RESULTS OF OXIDATION TESTS AT 700° C.

Material	Increase in Weight in mg./sq.cm. at 700° C. after 100 hr.	1,000 hr.	Remarks
Mild Steel	40·4	147·7	
Chromised Coatings			
A	0·04	0·15	
B	0·69	1·54	Exposed edges
Aluminium Coatings			
P	4·06	9·33	
Q	0·96	3·37	
R	6·68	13·8	
S	5·76	12·8	
T	1·9	9·63	
U	0·73	2·2	
V	0·8	3·81	Exposed edges
W	1·2	6·2	Exposed edges
X	2·27	7·27	Exposed edges
Commercial Enamel Coatings			
I	0·64	—	Coating spalled after 580 hr.
	0·64	—	Coating spalled after 1,000 hr.
D	1·74	11·55	
C	2·27	—	Coating spalled after 811 hr.
F	1·40	—	Coating blistered after 720 hr.
E	1·87	—	Coating peeled off in furnace after 720 hr.
G	1·10	8·8	
N.B.S. A.417 (*M*)	0·03	2·60	
N.B.S. A.19H (*X*)	1·22	5·65	9·22 mg./sq.cm. after 2020 hr.
N.B.S. Frit 331 (*O*)	0·16	6·81	
Fulmer Research Institute Coatings			
J	0·77	5·83	
K	0·93	5·08	
L	0·112	4·07	

TABLE II.—RESULTS OF OXIDATION TESTS ON ENAMEL COATINGS AT 800° C. AND 900° C.

Coating	Increase in Weight in mg./sq.cm. after 5 hr. at 800° C.	50 hr. at 800° C.	5 hr. at 900° C.	50 hr. at 900° C.
Uncoated Mild Steel	8·69	44·0	53·8	120·8
N.B.S. Frit 331 (*O*)	0·21	—	11·1	67·0
N.B.S. A.417 (*M*)	0·93	—	7·8	106·2
Fulmer *J*	—	9·8	—	66·5
Fulmer *K*	—	15·7	—	92·0

be pointed out, however, that these specimens had very much thicker coatings of aluminium than the other samples which were tested.

Commercial Enamel Coatings.

Many of the enamel coatings showed damage before completion of a test of 1,000 hours duration at 700° C. This damage usually occurred by the coating spalling on removal from the furnace for weighing. The ends of the full lines in Fig. 3 indicate the point up to which readings were taken, and the crosses the time at which the coating failed before it was possible to weigh the specimen ; the dotted portion of the curve shows the probable course of the curve to this point.

The only enamel coatings which withstood 1,000 hours at 700° C. without some spalling were *D* ; the National Bureau of Standards coatings A.417 (*M*) and A.19H (*N*) and Frit 331 (*O*) (which is the basis of coating A.417 except that the latter contains 30% Cr_2O_3) ; and Fulmer coatings *J*, *K* and *L*. Of these, the most protective was coating A.417 (*M*), which showed no weight increase at all up to about 200 hours of test, but which then gained weight at an increasing rate. However, at the end of 1,000 hours it was comparable with the best of the aluminised specimens.

The coatings changed in appearance with time at temperature. Most of them were initially glossy but soon became matte : this is probably due to volatilisation of some of the enamel constituents e.g. alkalis. This would certainly lead to a change in the coefficient of expansion, and is probably the cause of the deterioration of the reistance to thermal shock which led to failure in some cases on removal from the furnace in less than 1,000 hours. The slow volatilisation of coating constituents does not introduce any serious error into the gain of weight values, since the total weight of the coating per sq. cm. is only about 5 mg. and the losses can only be a small fraction of this.

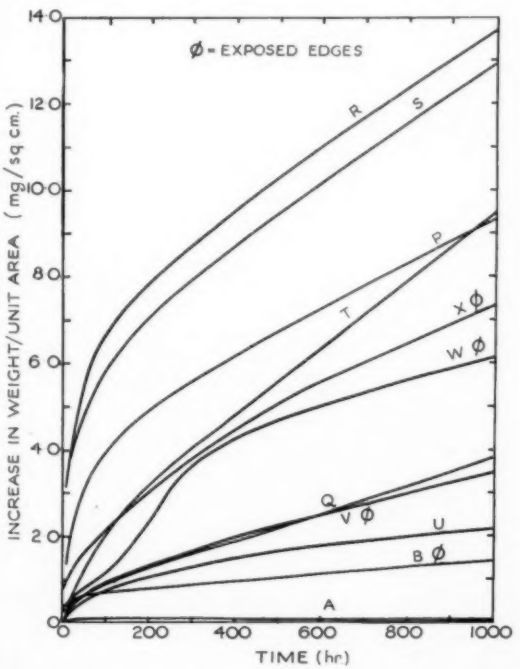

Fig. 2.—Oxidation curves of chromised and aluminium coated mild steel specimens at 700° C.

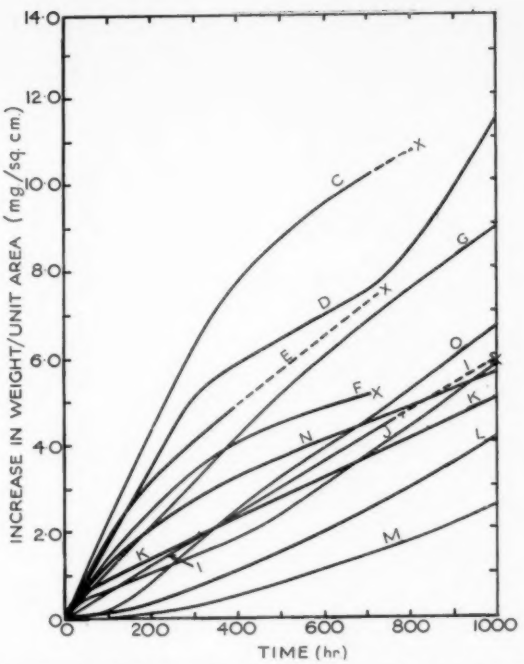

Fig. 3.—Oxidation curves for mild steel coated with various protective enamels at 700° C.

Short Term Tests on Enamel Coatings at 800° C. and 900°C.

The results of exposure for 5 hours and for 50 hours at 800° C. and 900° C. for some of the enamel compositions are set out in Table II, which also gives comparable figures for unprotected mild steel. For a short term exposure of 5 hours, some of the coatings provide substantial protection, the improvement ratio for coating A.417 (*M*), which was the most effective, being about 9·5/1 at 800° C. and 7/1 at 900° C. None of the coatings, however, afforded any substantial measure of protection in a test of 50 hours duration at 900° C. or, to a lesser extent, at 800° C.

Thermal Shock Tests on Coatings

Thermal shock tests have been carried out on enamel-coated specimens, in the unoxidised condition and after oxidation for 480 hours at 700° C. The tests were carried out on small test pieces of the same size as those used for oxidation tests. These were plunged into the centre of the work coil of a valve-operated high-frequency furnace which heated the samples at a rate of 100° C./sec. On withdrawal, the specimens were subjected to an air blast which cooled them at 10° C./sec. Each piece was given 25 cycles at these heating and cooling rates, with a maximum temperature of 200° C., 400° C. and 600° C. The results are set out in Table III.

The only apparent change in unoxidised specimens was a slight loss in their original gloss. Of the oxidised specimens, except for coating *K*, the coatings showed little change during the thermal shock tests. It may be concluded that most of these protective enamels are resistant to thermal shock of the severity likely to be encountered in service, when applied in thicknesses

TABLE III.—RESULTS OF THERMAL SHOCK TESTS ON COATINGS.
Condition after Thermal Shock (25 cycles at 200° C., 400° C. and 600° C.)

Coating	Initially Unoxidised Specimen	Specimen Oxidised 480 hr. at 700° C. before Test
N.B.S. A.417 (*M*)	Coating intact	Coating intact
N.B.S. A.19H (*N*)	Coating intact	Coating intact
Fulmer *J*	Coating intact	Coating intact
Fulmer *K*	Coating intact	Peeled after 8 cycles at 600° C.

adequate to provide a substantial measure of protection against oxidation at temperatures up to 700° C.

General Conclusions

The results which are presented above confirm that mild steel may be adequately protected against oxidation at 700° C., in long term exposures with intermittent heating and cooling, by chromising, or coating with aluminium or a suitable enamel. In terms of absolute resistance to oxidation, chromising is the most effective treatment. Although the oxidation-time curves for aluminium-protected specimens show larger weight increases than those for chromised specimens, the degree of protection afforded by aluminium is probably adequate for most applications at a temperature of 700° C. At higher temperatures than 700° C. chromising probably shows a greater superiority over aluminising, but no attempt has been made to assess this during the present work.

Certain of the enamel coatings tested show a striking degree of protection at 700° C., and may have many practical applications. Of the coatings tested, the most successful was National Bureau of Standards coating A.417, which applied at a thickness of 0·002 in. gave adequate protection over a period of 1,000 hours at 700° C. The composition and method of preparation of this and the other National Bureau of Standards coatings has been described by Harrison, Moore and Richmond[2]. Such coatings are easily applied by spraying an aqueous "slip," and are subsequently fired at a temperature of 900–1,000° C. for a period of the order of 3–5 minutes. Their use in long term applications is, however, probably limited to a temperature not much exceeding 700° C. At 800° C. and above, protection is afforded for only a very short period of time by the enamel coatings which have been tested.

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Die Casting Certification Mark Scheme

THE British Standards Institution and the Zinc Alloy Die Casters Association have together drawn up a Certification Mark scheme for zinc alloy die castings, which came into operation at the beginning of last month. Customers can now order castings guaranteed to be made under strictly controlled conditions subject to inspection by the B.S.I., and complying with the exacting requirements of B.S. 1004. This standard was published in 1942 to safeguard the quality of the millions of critical ammunition components being made from zinc alloy die castings.

Zinc alloy die casting is a quantity production process used in many industries to make parts, often complicated in design, which are strong and durable. To ensure that these qualities are realised to the full, it is absolutely essential to use only zinc alloys of carefully controlled composition. If certain impurities, notably lead, tin, and cadmium, are allowed to contaminate the alloy—even to the extent of a few parts in 100,000—the future behaviour of the castings becomes uncertain. Already in many foundries a strict routine is followed so that each year millions of reliable zinc alloy die castings are made for use in motor cars, electrical equipment, household fittings, light and heavy engineering components, and defence stores. But some customers are still not aware of the dangers they run by being "penny-wise" about zinc alloy die castings, and some firms are still prepared to supply cheap off-grade castings to the unwary or indifferent buyer.

The purpose of the Certification Mark scheme is to give the customer a guarantee that if he orders die castings from a firm licensed under the scheme, he will receive reliable castings complying with B.S. 1004. Wherever possible the castings will carry the Kite-mark "B.S.1004" and the die caster's name, trademark, or B.S.I. licence number. Castings too small to be marked individually will be supplied in specially labelled boxes.

The new scheme will be widely publicised both by individual licensees and by the Zinc Alloy Die Casters Association, which has sponsored it. Many firms have already had their works inspected by the B.S.I. and have been granted licences to use the Kite-mark. The Associations own advertisements will include a list of members who are licensed and the list will be kept up-to-date as other members come into the scheme.

If the B.S.I. finds that a licensee is supplying castings outside the specification he will be warned and, in persistent default, will forfeit his licence. Participation in the scheme is open to any die caster, whether or not a member of ZADCA, who is willing and able to comply with the conditions. Full particulars are obtainable from the British Standards Institution, British Standards House, 2, Park Street, London, W.1.

Vacuum Melting Methods

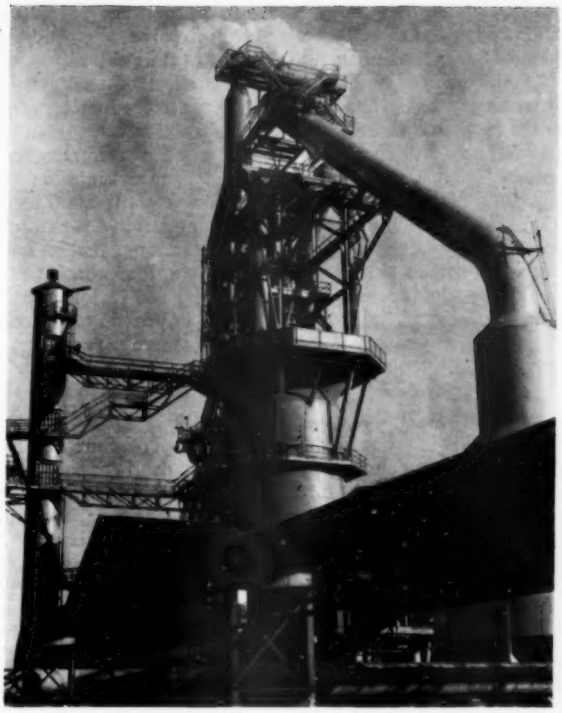
CRUCIBLE STEEL COMPANY of America and National Research Corporation have joined forces to accelerate developments of the vacuum melting of steels and other alloys. The steel company has acquired a 50% interest in Vacuum Metals Corporation which was formerly a wholly-owned subsidiary of National Research. Vacuum Metals is already producing vacuum melted steels and other metals in commercial quantities. Arrangements have now been completed for the construction of new vacuum melting facilities to be located in Syracuse, New York, in an expansion programme that is expected to increase Vacuum Metals' capacity by more than 500% in the next twelve months. Adequate commercial availability of these high purity metals is expected to aid important developments in the production of critical parts of jet engines, to improve the life and performance of electronic tubes, and to increase the reliability of precision instruments used in automatic control systems.

Extensions at Appleby-Frodingham

New Blast Furnace Blown-in at South Ironworks

THE seal was set on a further stage in "Operation Seraphim," the South Ironworks extension scheme at Appleby-Frodingham, when Sir Walter Benton Jones, Bt., chairman of the United Steel Companies, Ltd., blew in the first new blast furnace last month. In his speech on that occasion, Sir Walter referred to the great strides made in iron manufacture in the last 80 years. In 1873, there were 13 blast furnaces in Lincolnshire, of which 9 were in blast: the total pig iron produced amounted to about 52,000 tons, with an average output per furnace in blast of some 5,786 tons per annum. In contrast, the total number of furnaces in 1953 was still 13, 12 being in blast, but the iron produced totalled 1,560,000 tons, or 130,000 tons per annum per furnace. Of the 1953 total, Appleby-Frodingham, which began the year with 7 furnaces, made 975,000 tons. When the two latest furnaces are built, South Ironworks will be a four-furnace plant which is expected to produce 1,300,000 tons a year, with a furnace average of 325,000 tons.

The object of Operation Seraphim, which will cost £12 million, is to improve further the technical efficiency of iron making, and to increase iron-making capacity to a figure exceeding 1¼ million tons a year. About two-thirds of this iron will be used for steelmaking by the hot metal process at Appleby-Frodingham, and the remainder will be pigged for use at other United Steel works. Before blast furnace practice could be improved, research had to carried out, and before increased outputs could be effectively used, other expansion and modernisation had to take place. Since the war, and before Seraphim, £13·5 million (about £20 million at present day prices) has been spent on iron making, steel making and rolling mill developments.



No. 3 Blast Furnace at Appleby-Frodingham

Sir Walter Benton Jones, Chairman of United Steel, lights the furnace.

The New Furnace

The scheme includes two new blast furnaces: that just blown in has a 27 ft. diameter hearth and is the largest in the country, whilst its neighbour will have a hearth diameter of 28 ft. 6 in., a height of 217 ft., and will be the largest in Europe. The combined annual output of the two furnaces is estimated at 500,000 tons. The 27 ft. furnace has a working volume of 43,000 cu. ft., and is equipped with 18 hearth tuyeres and 9 bosh tuyeres. Carbon refractories are used exclusively for the hearth and bosh, but the stack is lined with orthodox firebricks.

Using a 100% sinter burden it is hoped that output of well over 6,000 tons a week will regularly be attained: this, it will be recalled, is more than the average Lincolnshire furnace made in a whole year in 1873. This output must, of course, be considered in the light of the quality of ore smelted. Because of the low average iron content of 24%, the ore has to be prepared before charging into the furnace, and this preparation plant forms consider-

ably the largest part of the works layout. In spite of the improvement in quality resulting from this treatment, the production of 6,500 tons of iron involves the production of 8,500 tons of slag, making a total liquid output of 15,000 tons per week. The production of such large quantities of slag has necessitated the introduction of a third slag notch in addition to the usual two.

The ore crushing plant consists of a primary roll crusher and two secondary cone crushers capable of crushing 800 tons of ore per hour, or about 140,000 tons per week. Screening, before and after crushing, separates the fine (less than 1 in.) ore which is tertiary crushed and diverted to the sinter plant, where the four continuous moving-pallet strands, 72 in. wide and 168 ft. long, with 28 windboxes, operating on the improved methods devised during the last few years, have a combined capacity of 28,000 tons of sinter a week.

Blowing Equipment

The blowing equipment will consist of four steam-turbine-driven centrifugal blowers, each capable of delivering 75,000 cu. ft./min. of air (at 0° C. and 760 mm. Hg) against 30 lb./sq. in. gauge pressure. Steam will be raised in four water-tube boilers, each having a capacity of 85,000 lb./hr. at 450 lb./sq. in. pressure. Two of the boilers and one of the turbo-blowers are in operation. The plant for cleaning the blast furnace gas is of modern type, and includes dust catchers, cyclones, washers and electro-static precipitators.

A 190 ft. high reinforced concrete tower carries two water-storage tanks each holding 1,500 tons of water and providing a half hour emergency supply to the blast furnaces and the gas cleaning plant. All cooling systems are closed circuits to conserve water, and the hot used water is passed into a reinforced concrete natural draught cooling tower, which is 180 ft. in diameter at the base and 285 ft. high. The cooling tower has three separate sections, to deal with water from the turbine condensers, the gas cleaning plant, and the blast furnace cooling system. Water from the gas cleaning plant is clarified in three clariflocculators before cooling.

The contractors for the blast furnaces are Ashmore, Benson, Pease & Co., Ltd., Stockton-on-Tees; for the blowing equipment, the Parolle Electrical Plant Co., Ltd., Newcastle-upon-Tyne; for the gas-cleaning and sinter plants, Head Wrightson & Co., Ltd., Thornaby-on-Tees; and for the primary and secondary ore crushers, Ross Engineers, Ltd., Surbiton, Surrey. The chief designer at Appleby-Frodingham is Mr. I. M. Kemp. And from some of these initial letters, together with S and E for South Ironworks Extensions, "Seraphim" was derived.

New Philips Film

A NEW black-and-white sound film "A New Approach to Production Improvement," whose completion has recently been announced by the Industrial Division of Philips Electrical, Ltd., is meant to be part of the "Philips in the Service of Industry" policy typified by the extensive facilities offered at the Philips Industrial Centre, London.

The film, which has been made with the co-operation and help of 17 widely differing industrial undertakings, opens at the Application Centre, where many types of production equipment can be demonstrated, and where production problems are continuously under investigation in close co-operation with manufacturers. The Centre serves as a central link to bind together the many stories of industrial and scientific achievement told in the film.

The subsequent sections cover resistance welding: the application of electronic measuring instruments in industry; the removal of unwanted contamination from fluids; high frequency induction and dielectric heating; and arc welding. In each section both standard practice and the latest developments are dealt with, and the film concludes where it began, in the Philips Industrial Application Centre, where a compact team of design, research and production engineers, metallurgists, draughtsmen and operators are ready to advise industry.

Copies of the film are available in 16mm. and 35mm. sizes, and they will be loaned free of charge to film societies, engineering societies, technical colleges, industrial undertakings, etc. Application should be made, with as long notice as possible, to Industrial Application Centre, Philips Electrical, Ltd., 122, Brixton Hill, London, S.W. (Tel.: Tulse Hill 4652).

A group of semi-automatic welding heads contact arc welding wagon break beams whilst the operator tacks the next job.

The Royal Society

AMONG the list of those recently elected Fellows of the Royal Society were the following:—

FREDERICK CHARLES FRANK, Reader in Physics, University of Bristol. Distinguished for his original contributions to the theories of crystal growth, of plastic deformation and of dislocations in crystalline solids.

SIR CHRISTOPHER HINTON, Managing Director, Industrial Group, Department of Atomic Energy. Distinguished as an engineer who, by his leadership and by direct contributions, has played a major part in the development of large production plants in the Atomic Energy Project.

ALFRED JOHN SUTTON PIPPARD, Professor of Civil Engineering, Imperial College of Science and Technology, London. Distinguished for his theoretical and experimental contributions to the theory of structures.

THE BRITISH INDUSTRIES FAIR

Engineering Exhibits at Castle Bromwich

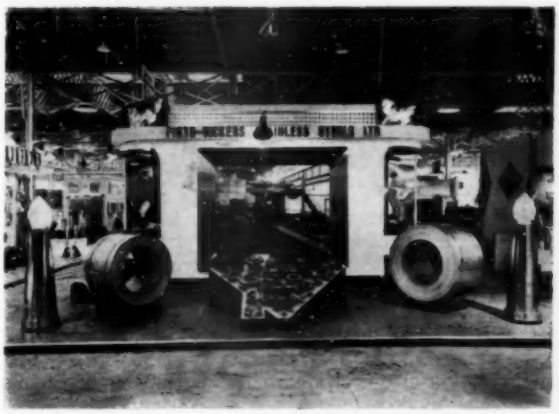
Although the finances of the country are, in some respects at least, better than they were a year ago, the fact remains that we must export to live, and every effort must continue to be made, not only to maintain our volume of exports, but, if possible, to increase it. The British Industries Fair will provide an opportunity for overseas buyers to see a cross-section of the goods we have to offer, and in this survey of exhibits attention is mainly directed to metallurgical aspects of the Engineering Section

AFTER bathing in the reflected glory of the Coronation last year, the 1954 British Industries Fair will mark a return to "business as usual." This, the thirty-third of the series started in 1915, will be the last Fair to be held under the management of the Board of Trade. In future, the management will be left in the hands of a public corporation, whose members will be appointed by bodies representative of British industry and trade, with one member appointed by the Government. But the object of the Fair will remain the same, namely, "to project British Industry on the World and be a pageant of the best in British industry." The 1954 Fair will itself be affected by some important changes in emphasis and organisation in response to changing circumstances, but these will concern the London sections more than the Birmingham section, which will continue to be organised by the Birmingham Chamber of Commerce. There will, however, be a number of changes at Castle Bromwich, and several exhibitors who have been ever-presents for a number of years will not occupy stands this time. Continued support will be given by the non-ferrous metals industry, but a number of important firms in the wrought and cast ferrous metals field will be absentees; and whilst metal finishing exhibits, for instance, appear to be on the increase, well-known firms in the refractories, machine tool, oil and electrical equipment sections will not be showing. This is not to suggest that interest will be wanting, as may be judged from the following survey, but it may be regarded as the continuation in certain sections of a trend which began a year or two ago.

In the space available, no more than a brief indication can be given of the exhibits at Castle Bromwich which are likely to be of interest to those concerned with the production and use of metals in their various forms. In the following pages the exhibits are, in the main, classified according to their nature, the name of the exhibitor being given in the text along with the stand number. Almost all the exhibits referred to will be found in Sections C and D.

Wrought Steel

THE UNITED STEEL COMPANIES, LTD., will again house their display on Stand D.519/416, designed by Design Research United of London, under the direction of the Publicity Department of the Company, who will also be responsible for the whole administration connected with the running of the stand. Details of the design will incorporate a general survey of the Companies' products in the form of external display murals, constructed of actual material in a variety of forms manufactured by each Branch. There will also be unique models in abstract form to indicate products covering the main field of activities in the industry. The general story of The United Steel Companies, Ltd., will be further told by colour photographs forming the murals for the interior of the stand. General display principles have been carefully thought out to maintain a high prestige value and, in addition, full facilities will be provided for the reception of guests. A separate room will be available for private discussion, and a full staff of technical representatives will be in attendance during the whole period of the exhibition.



Courtesy of Firth-Vickers Stainless Steels, Ltd.

Rear view of the Firth-Vickers stand showing two 3-ton coils of 37 in. wide Staybrite strip.

Some of the greatest developments in steel during recent years have taken place in the field of stainless and, more particularly, heat-resisting steels, as a result of the impact of the jet engine and other forms of gas turbine. Important contributions to this progress have been made by FIRTH-VICKERS STAINLESS STEELS, LTD., who will be showing, on Stand D.419/318, corrosion- and heat-resisting steels in the form of sheet, bar, strip, forgings and castings. Prominent among the exhibits will be two coils of 37-in. wide softened and descaled Staybrite strip, each weighing approximately 3 tons.

Railway track engineers will be interested in Stand D.503/400, where EXORS OF JAMES MILLS, LTD., will display specimens of their rail track fastenings. The Aladdin rail and wheel flange lubricator for reducing wear on the curves of railway track will also be exhibited. The display will include a range of bright drawn steel bars (of which the Company are the largest makers outside the United States), and components made in Ledloy high-speed machining steel, together with keys, cotter pins, taper pins and Mills' patent grooved pins and studs.

On Stand D.329 J. B. & S. Lees, Ltd., will be showing a range of hot and cold rolled strip in both low and high carbon steels, special emphasis being laid on the Company's main speciality, which is hardened and tempered steel strip for bandsaws, handsaws and other spring steel work. Another speciality, probably of greater interest to overseas buyers than to British, will be lead-coated steel strip.

Well known in the field of rolled steel products, Arthur Lee & Sons, Ltd. (D.530) will be showing a selection of bright steel bars, cold-rolled steel strip, high grade steel wire, stainless steel strip and wire—all principal manufactures of the company—along with a selection of articles made from stainless steel.

Attention is also drawn to the stands of the Brockhouse Organisation (D.405/304) whose exhibits will include drop forgings and cold rolled sections; Willmott Taylor, Ltd. (C.413)—nickel-plated, brass-plated and tinned steel strip in coil; Padley & Venables, Ltd. (D525/422)—stainless steel in the form of sheet, strip, bar, tubes, sections, wire and finished articles.

Ferrous Castings

The introduction of new mechanised plant at the Tipton foundries of Hale & Hale (Tipton), Ltd., will enable the firm to offer to B.I.F. buyers early delivery of castings in both Blackheart malleable iron and in Permalite, a special purpose high-duty iron, developed in the Hale laboratories, which has a tensile strength of 33–35 tons/sq. in., a yield strength of 20–22 tons/sq. in., an elongation of 6–8%, and a bend of 90°. Increasing use is being made of Permalite, particularly for winches, gear housings, gear blanks, brake drums, bushings and other components used in the manufacture of vehicles, heavy industrial machinery, contractors' plant, etc. Examples of both light and heavy castings, some newly developed, and others already familiar to visitors to the Fair, will be displayed on Stand D.609/508. They will include examples of interest to visitors representing such fields as agricultural machinery, building and civil engineering, electrical engineering, mining, automobile engineering, railways and shipbuilding.

Blackheart malleable castings will also be featured on Stand D.709 (Follsain-Wycliffe Foundries, Ltd.) where the exhibits will also include a number of examples of castings in C.Y. alloy. This material is not intended for resistance to shock, but its tensile strength at 30–35 tons/sq. in. makes it stronger than cast iron. Its main feature is its abrasion resistance; it is claimed to outlast chilled iron by 3–5 times.

John Harper & Co., Ltd., are well known in the field of iron castings, one of their lines being the production of castings in Meehanite, and although their stand (A.336) is in the hardware section and will feature a range of manufactured products, there will also be a representative show of high-duty Meehanite and grey iron castings for the engineering and electrical trades. Special features of the display will be cast crankshafts and castings made by the shell moulding process.

Reference has already been made in the previous section to the fact that stainless steel castings will be shown on the stand of Firth-Vickers Stainless Steels, Ltd. (D.419/318), the exhibits including ordinary static castings, centrifugal and centri-die castings and precision castings.

As might be expected from the name of the Company, H. & F. Precise Castings, Ltd., will have on view on Stand A.327/226 a range of precision castings in steel and other alloys. They will include: nozzle guide vanes and other parts for gas turbine engines in heat resisting steel; castings in low alloy steels for textile and shoe-making machinery, to replace forgings and parts machined from bar stock; castings for textile machinery in chrome cobalt and other wear resistant alloys; cast milling cutters in high speed steel; stainless steel castings for small lathes; and surgical and dental castings in chrome cobalt. A wide range of Stellite castings shown by Deloro Stellite, Ltd., on Stand D.402 will include numerous examples of those of the precision type.

On the Brockhouse stand (D.405/304), three of the firms represented are makers of ferrous castings: Brockhouse Castings, Ltd.—iron and steel castings; R. J. Hunt & Son, Ltd.—grey iron castings; and Meldrums, Ltd.—grey iron and acid-resisting castings.

Non-Ferrous Metals

The British Non-Ferrous Metals Federation was formed in April, 1945, as the representative organisation of the fabricators of copper and copper-base alloy products, and of zinc. The membership of the Federation consists of ten Trade Associations, covering the whole range of rolled, extruded and drawn non-ferrous metal products, for both electrical and non-electrical uses. The Federation stand (D.219) will serve to facilitate relations between home and overseas buyers and the industry, by providing opportunities for contact with representatives of the whole industry, and by having available information on federated firms and their products.

The attractive colour finishes obtainable with copper and its alloys will be used to good effect on the new stand of the Copper Development Association (D.232). The entire surface of the main stand structure will be covered with 7-in. square tiles of copper, brass, nickel silver and gilding metal. The effect will not only be highly decorative, but will serve as a useful reminder that copper and copper alloys are fully available for unrestricted use. The design of the stand, by the Association's Architectural Consultant, Mr. A. L. McMullen, M.A., F.R.I.B.A., will include on the left a small projecting screen, also faced with metal tiles. On the outer face of the screen will be an attractive sculptured display by Mr. A. W. Farmer in copper sheet in contrasting tones. Five display recesses, two in the side screen and three at the front, will contain photographs of applications of copper and copper alloys, and advice to users that "To Make the Most of Copper" they should "First Ask the C.D.A.," a hint which often saves much time, worry and expense. Also on the stand will be some striking examples of uses of copper and copper alloys, and the full range of the Association's excellent free publications.

For many years, Thomas Bolton & Sons, Ltd., have played a leading part in the development and manufacture of copper and its alloys for use in the electrical and other industries, and the exhibits on Stand D.518 will indicate the uses to which the Company's products are put. On the electrical side, there will be bare wire and strip in copper, brass and bronze; H.D. H.C. copper busbars and end rings for rotor and stator coils; commutator segments in H.C. copper and Combarloy; and Bolton's patent cellular conductor for extra-high tension busbars of outdoor sub-stations. Marine

engineering applications will include condenser plate, copper tubes, equaliser bars, extruded and drawn sections, copper ingots and chill cast phosphor bronze. For building there will be copper tubes for water, gas and sanitation services and for burial underground; for textiles, copper printing rollers; and for aircraft a display of piston and jet engine parts. Cadmium copper is widely used for spot and seam welding electrodes, and a special series of alloys for this purpose, Durode, Durode XH and Durode CC have also been developed.

Of particular interest on the stand of I.C.I. METALS DIVISION (D.409/308) will be the display of wrought titanium. I.C.I. are devoting £3½ million to building plants for the manufacture and processing of this metal. Apart from a general display of metal products in copper, aluminium and their alloys, there will be special exhibits showing specific applications in the building, transport and electrical industries. Modern developments in the use of Kynal aluminium alloy for roofing will be shown; and uses of Kudampro copper damp course strip; I.C.I. copper expansion joint strip for concrete structures; and Terrabond serrated brass or aluminium strip for terrazzo work will be illustrated, as will tubes and fittings for gas, water and waste services. The Division's widespread interest in the transport industry will be emphasised by displays of tubes (including Kunifer 30 and Alumbro) for condensers; Kynal aluminium alloy sheet and extrusions for ships, lorries, buses and railway rolling stock; and copper plates and rods for locomotive fireboxes. Products for the electrical industry will include condenser tubes and plates for power stations; copper wire and tape for the telegraph, telephone and cable industries; copper and aluminium extrusions for switchgear; and Kynal solders and flux for soldering aluminium. One section of the stand will feature numerous products of the Metals Division used in heat-exchange work. This will include examples of Integron High Fin and Low Fin tubing applicable to many forms of heat-exchanger—in particular, refrigeration condensers.

The MCKECHNIE BROTHERS stand (D.500) at this year's Fair will be larger than in former years, and the exhibits displayed thereon will indicate the ever-widening ramifications of this Company. Among the many examples of MKB products on view will be extruded rods and sections in brass, bronze, nickel silver and copper. Visitors will be impressed by the magnitude of the MKB output of high-speed screwing brass rods, brass and bronze stampings, chill cast bars, anti-friction metals and non-ferrous ingots. Another interesting display will feature sulphate of copper, electrolytic copper powder, copper cathodes and lithopone—all of which are produced at the Widnes Works of the Company in Lancashire. The range of MKB products will be completed with a display of "Spider Brand" and other solders which are produced at the MKB Works in Stratford, London.

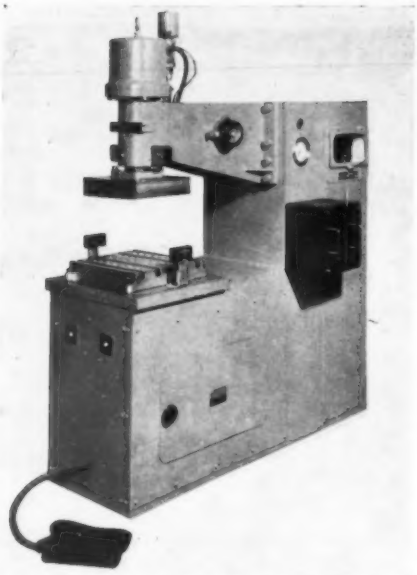
As usual, the emphasis of the display of THE DELTA METAL CO., LTD., on Stand D.311, will be mainly on extruded sections, those on view ranging from rods weighing but a few ounces per foot run to massive sections of up to half a hundredweight per foot, or more. A prominent feature of the stand will be the ornamental pavilion forming the office, constructed solely of Delta Bronze No. IV and Delta No. II Silver Bronze sections, illustrating the use of these materials for architectural metal work. These alloys, particularly the Silver Bronze, have been very widely used for decorative work in passenger liners built in recent years. High speed free-cutting brass will be in evidence on the stand, together with aluminium bronze for aircraft work, high conductivity copper for electrical work, and brass for hot stamping: specimens of extruded zinc rods and non-ferrous welding rods will also be on view. Associated firms of Delta Metal will be represented by extruded hollow rods (EXTRUDED METALS CO., LTD.), light section and hinge bars (MOORE BROS., LTD.), rolled and drawn metals (HEATON & DUGARD, LTD.), and brass and copper tubes and strip, and brass sheets (EARLE, BOURNE & CO., LTD.).

The N. M. ROTHSCHILD & SONS stand (D.330) will show a range of copper, brass, cupro-nickel and gilding metal strip, predominant in which will be copper and brass foil, in varying widths, according to gauge, from 10 in. down to ¼ in. On view, for the first time, will be electrolytically-deposited copper foil, in coils 18 in. wide. It has a matt surface on one side and can also be supplied tinned or silver-plated; narrow width coils around the 0·0005 in. (0·015 mm.) thickness range will be of great interest to the condenser industry. Similar foil, but 0·0015 in. thick, will be shown bonded to sheets of plastic laminate for the production of printed circuits, and actual examples of circuits may be seen. There appears to be great interest abroad in this electrolytically-deposited foil, and enquiries have been received from Sweden, Denmark, Holland, Germany, Italy, Poland and the United States. The use of precious metals for industrial purposes will be illustrated principally by the well-known Silverlink range of silver solders in rod and strip; gold and silver anodes for plating baths; and various forms of alloy trip. Wire for the electrical and cable industries will also be shown coated with precious and other metals.

On Stand D.514 THE BIRMINGHAM BATTERY & METAL CO., LTD., will be showing a representative selection of tubes, plates, sheet, strip, rod and wire in copper and copper alloys. The company for many years has specialised in heavy and large non-ferrous products and a yellow metal plate 10 ft. 6 in. in diameter and 1¼ in. thick, will be prominently displayed, along with large diameter brass and copper solid drawn tubes which will indicate the splendid finish necessary for roller tubes for the paper and textile industries. Also displayed will be a replica of a typical heat exchanger equipped with tubes of Batalbra and other alloys. During recent years the use of aluminium-bronze condenser tubes has gained favour in the oil refining industry, because of their increased resistance to corrosion and examples of tubes in these alloys will be exhibited. Samples of bi-metal tubes will also be shown to represent tubes which will withstand different kinds of corrosive action inside and outside.

No details are yet to hand of the exhibits of JOHN HOLROYD & CO., LTD. (D.210), whose products include finish machined bushes and gear blanks; centrifugally cast tubes; chill-cast bar in Spuncast Holfos Bronze (centrifugally cast), Super Holfos Bronze (centrifugally cast), and Holfos Bronze (chill cast); and worm reduction and other gear units.

Wrought non-ferrous products will also be featured by BARKER & ALLEN, LTD., on Stand D.507, where the exhibits will include nickel-silver and cupro-nickel sheet, strip and wire in all qualities, together with brass, copper and bronze; and by GUESTS BRASS STAMPING



Courtesy of Sciaky Electric Welding Machines, Ltd.

Type PA50/150 multiple projection and cross wire welding machine.

Co. (D.732) and HOT PRESSED PRODUCTS (B.520) who, as their names imply, will put on displays of hot pressings in copper-base alloys.

Reference has already been made in the previous section to the precision castings being shown by DELORO STELLITE, LTD., and H. & F. PRECISE CASTINGS, LTD., some of which are in non-ferrous alloys, but there are a number of stands on which the more common non-ferrous alloys will be shown in the form of castings. These include D.604 where CHARLES CARR, LTD. (incorporating THE NON-FERREOUS CASTING CO. (BIRMINGHAM), LTD.,) will be showing castings in various brasses and bronzes ; castings made by the shell moulding process ; chill cast phosphor bronze rods (both solid and cored) ; non-spark tools in aluminium bronze for use in the petroleum, mining and chemical industries ; and brass brazing solder. On Stand D.616/717, C. & L. HILL'S exhibits will include Hilchil phosphor bronze bars ; a selection of non-ferrous sand castings ; aluminium gravity die castings ; and shell moulded castings ; whilst KAYE ALLOY CASTINGS, LTD., on the BROCKHOUSE stand (D.405/304) will be showing gravity and pressure die castings in aluminium and zinc base alloys.

Welding

The Type PA.50/150 multiple projection and cross wire welding machine to be shown by SCIAKY ELECTRIC WELDING MACHINES, LTD., on Stand C.222 has been developed for completing a large number of welds simultaneously in wire mesh for an exceedingly economic mains loading. The transformer is connected in series with and close up to the bottom tee slot platens, so that there is virtually no secondary loop, thus producing a very high electrical efficiency. There will also be on view a Type RAMU.75 universal seam welding machine, with a nominal rating of 75 kVA., a working throat depth of 26 in., and a welding capacity up to 16 s.w.g. plus 16 s.w.g. mild steel and stainless steel. Welding speed is under infinitely variable regulation from 3 to 12 ft./min. The machine is fully automatic and the weld control can be by modulator or by fully synchronous ignitron panel incorporating phase-shift heat control. Other exhibits will include a Type SAC.25 spot and stitch welding machine with a nominal rating of 35 kVA. when fitted with 16-in. arms, and 25 kVA. with 24 in. arms. The change-over from single spotting to auto-continuous stitch seam welding is by tumbler switch.

Some eighteen electric resistance welding and heating machines will be on view on Stand C.620/719 (HOLDEN & HUNT, LTD.), most of them capable of being demonstrated. The exhibits will include four universal pedal-operated spot welding machines varying from 5 to 25 kVA. capacity, together with a machine typifying a complete range of pedal- and air-operated machines for the Canadian and U.S. markets, and conforming in every way with C.S.A. requirements. Additionally, a 50 kVA. air-operated machine will be featured. A range of auto wire butt welders ranging from 3 to 30 kVA. will also be available for inspection, with various forms of clamping control.

In the arc welding field, a range of electrodes and arc welding accessories will be displayed by INVICTA ELECTRODES, LTD., on the OWEN ORGANISATION stand (D.616/717), and the exhibits will include a number of new and improved types of electrode recently marketed by the Company.

A new aluminium welding and brazing flux, on which tests are now being carried out to confirm its non-corrosive nature, will be shown on Stand D.129 by PLUS GAS CO., LTD. Known as Red Uniflux 10X, it is suitable for welding aluminium and aluminium alloys containing up to 10% magnesium, and for brazing aluminium and aluminium alloys containing up to 5·5% magnesium. It is also suitable for welding magnesium alloys and aluminium alloys containing more than 10% magnesium, provided that the normal after-welding practice to avoid corrosion is followed. Green Uniflux, also to be seen on this stand, has been developed

Courtesy of Holden & Hunt, Ltd.

No. 3 auto butt wire welder.

for brazing aluminium and aluminium alloys containing up to 2·75% magnesium to stainless and high quality non-stainless steels. For the soldering of aluminium and its alloys, Uniflux aluminium solder, a new low temperature (280° C.) solder, will be on show.

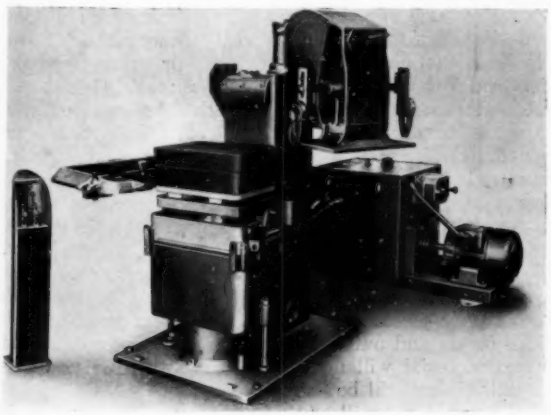
The emphasis on the stand of SUFFOLK IRON FOUNDRY (1920), LTD. (D.620) will be mainly on the Sifbronze welding advisory service, giving technical information and advice to customers. The exhibits displayed will include oxy-acetylene welding rods, fluxes and equipment, and it is hoped to have available a completely new booklet on stainless steel, and a revised leaflet on the welding of zinc-base die castings.

Rolls for Rolling Mills

The imposition of rigid specification for a rolled product in the ready-to-use and true-to-gauge condition, has necessitated rolls possessing the ideal surface structure, to suit a wide range of product, whilst the introduction of continuous rolling with the attendant changes in bearing design has led to radical revision of tolerance limits. The continued need for improvement has presented new and difficult problems to the roll maker. Such opposed characteristics as hardness and toughness, wear resistance and heat resistance, rigidity and flexibility, must be combined to give optimum results. A wide range of rolls exhibited by THE BRITISH ROLLMAKERS CORPORATION, LTD., on Stand D.617/516, will include examples for use in both the ferrous and non-ferrous fields for continuous wide strip mills, billet mills, section mills and sheet rolling mills. The latest development in roll making will be represented by a plate mill roll in spheroidal graphite iron.

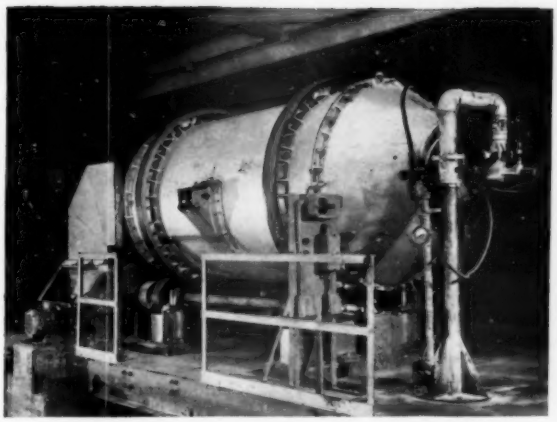
Foundry Equipment

One of the most important developments in the foundry industry in recent years has been the introduction of the shell moulding process, in which castings are poured into moulds consisting of thin "shells" or "biscuits," made by investing a hot metal pattern plate with a mixture of sand and a phenolic resin and baking in an oven. The main advantages of the process include dimensional accuracy, reduced fettling and machining, good finish, high yield, simplicity and cleanliness, and indefinite storage of shell moulds before



Courtesy of Foundry Equipment Co., Ltd.

H.E.B.1 boxless high speed moulding machine.



Courtesy of Monometer Manufacturing Co., Ltd.

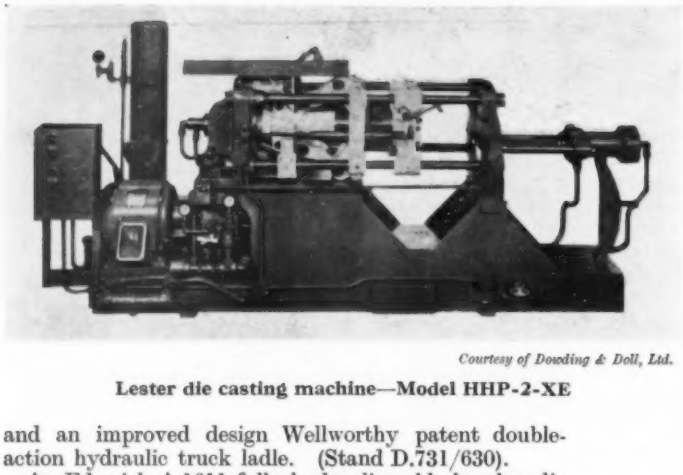
Fully mechanised oil-fired rotary furnace.

casting. BAKELITE, LTD. (Stand C.404), will be showing resins specially designed for this process, together with examples of moulds and cores. The Company has recently carried out considerable research with a view to establishing the most satisfactory method of carrying out the process.

One of the machines being demonstrated by FOUNDRY EQUIPMENT, LTD., on Stand D.301/200, will be the S.P.10 semi-automatic shell moulding machine, which has been introduced specifically for short-run production. It can be purchased as a double station machine, complete with the necessary auxiliary equipment, or it can be installed as a single station machine with the possibility of adding a second station later. Heating of the "biscuit" is by electric oven. Another interesting exhibit on the stand will be the H.E.B.1 boxless moulding machine. Hydraulic power is provided by a compact oil pump unit, and both cope and drag are rammed simultaneously. Operating together will be an S.P.220 F.E. (Sutter) automatic vertical core-blower and an S.P.520 double rollover core stripping machine. The combined unit is capable of producing up to 240 cores per hour, with a weight of up to 75 lb. each, using only one operator. Other exhibits to be demonstrated include rollover and jolt-squeeze moulding machines, a sand-rammer, a vibratory knockout and sand mills.

On Stand D.117, THE FULLERS' EARTH UNION, LTD., will be showing, among their other exhibits, Fulbond for bonding foundry moulding sands. The use of Fulbond with silica and natural sands will be demonstrated on test apparatus, and a number of moulds and cores will be shown to which Fulbond has been added to give them green strength.

In order to show a more comprehensive range of equipment for melting metal and for handling it in the molten state, the stand of MONOMETER MANUFACTURING CO., LTD., has been doubled in size. On the melting side, there will be a fully mechanised rotary furnace for both ferrous and non-ferrous metals, and a new design of semi-rotary furnace for non-ferrous metals. On a smaller scale, a new design of lip-axis hydraulic tilting crucible furnace, lift-out and bale-out crucible furnaces, and temperature controlled valve-outlet whitemetal and lead melting furnaces will be shown. For handling molten metal, there will be fully mechanised hot metal receivers for holding iron after tapping from the cupola,



Courtesy of Dowding & Doll, Ltd.

Lester die casting machine—Model HHP-2-XE

and an improved design Wellworthy patent double-action hydraulic truck ladle. (Stand D.731/630).

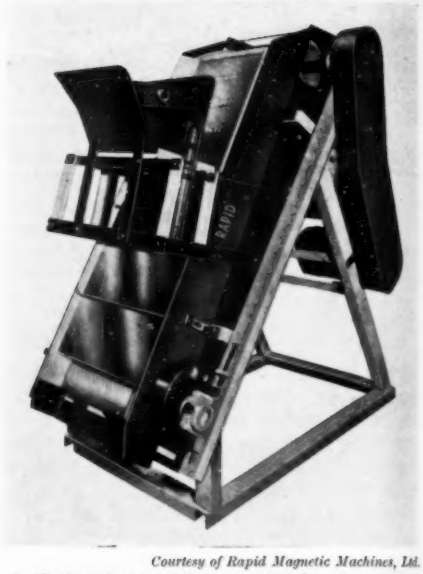
An Edgwick A.1611 fully hydraulic cold chamber die casting machine for aluminium, magnesium and brass will be shown in operation on Stand D.218 (ALFRED HERBERT, LTD.). The die plates of this machine measure 16 × 12·5 in., the locking pressure is 50 tons, and the casting capacity is 1¼ lb. The machine is equipped with hydraulic ejector mechanism and a nitrogen bottle to give higher speed to the injector stroke than that provided by the pump alone, and to avoid excessive drop in pressure.

The Lester HHP-1-CC die casting machine for aluminium, brass and magnesium to be shown by DOWDING & DOLL, LTD., on Stand D.537/434 is a self-contained model equipped with the Lester "slow squeeze" cold chamber injection system. It has a one-piece cast steel beam-type frame conservatively rated at 130 tons locking pressure, and the size of the die plates is 21 × 22 in. The die movement and metal injection cycles are controlled by electric timers. The HHP-2-XE machine, which will also be on show, is a smaller machine and has a die locking pressure of 100 tons.

Also of interest to foundrymen will be the magnetic equipment shown by ELECTROMAGNETS, LTD. (C.605), and RAPID MAGNETIC MACHINES, LTD. (C.421); the dust control equipment by DALLOW LAMBERT & CO., LTD. (D.427/326); and the KEITH BLACKMAN fans (D.521/418). More detailed reference will be made to these under the heading of "Miscellaneous."

Tubes and Pipes

The use of higher temperatures for power station steam raising plant has led to the development of steels, fabrication techniques and heat treatments especially suitable for steam pipework, to ensure a safe and efficient working life under the most arduous conditions. AITON & CO., LTD., who specialise in this class of work, will show on their stand (D.608) a 9 in. bore × 1·56 in. thick austenitic steel steam pipe, designed for service at 1,665 lb./sq. in. pressure and 1,070° F. temperature. This pipe has two plain bends and several welded-on attachments for instrument connections, etc. Also on this stand will be found a sectioned end of a 30 in. bore steam receiver, illustrating the scantlings and constructional features, for steam service at 650 lb./sq. in. pressure and 850° F. temperature. This exhibit is fitted with a 12 in. bore Corwel branch sectioned to show the deep groove welding in the body. A 3½ in. bore



Courtesy of Rapid Magnetic Machines, Ltd.

Self-cleaning multi-separator for extracting coarse and fine iron from chippings, borings, crumb rubber and similar granular materials.

auxiliary steam branch and associated drain vessel are fitted also, to illustrate the latest requirements of the British Electricity Authority to combat possible corrosion fatigue in pressure vessels. Aiton & Co., Ltd., will also be showing working exhibits in both full size and model form, together with examples of their various types of expansion joints, steam traps, corrugated pipes, and a large bore cast-iron special pipe.

THE YORKSHIRE COPPER WORKS, LTD., will break with tradition this year with a single tier stand (B.723/634), on top of which will be mounted a bank of copper tubes ranging in size from 24 in. to 6 in. diameter. On the front and the sides of the main feature there will be mounted large coloured photographs of ships, power stations, oil refineries, refrigeration plant, etc., depicting the wide range of industries and trades which use Yorkshire non-ferrous tubes and Yorkshire fittings. At the rear of the stand, six interesting panels will deal, respectively, with (*a*) waste installations; (*b*) heating and large size pipelines; (*c*) gas services, carcassing and installation pipelines; (*d*) underground water pipelines; (*e*) bottled gas, general engineering, refrigeration and low pressure steam services; and (*f*) hot and cold water services, together with large photographs showing panel heating installations. A further four panels will be devoted to fittings. Special displays arranged round the perimeter of the stand will be representative of the diverse range of products manufactured by Yorkshire. These include tubes in copper, brass, cupro-nickel, Yorcalbro, Yorcoron, Yorcunic and Yorcunife for condensers, heat exchangers, salt water systems, refrigerators, etc., and fittings for use with these tubes. For situations where the corrosive conditions inside and outside the tube are so different that a single material will not withstand both, duplex or bimetallic tubes will be shown.

The new tube mill of SERCK TUBES, LTD., is now in full production, supported by specialised vertical extrusion processes and a newly installed induction melting

plant, and the Company is marketing an increased tonnage of solid-drawn non-ferrous condenser tubes; tubes for sugar refining plant and oil refineries; and tubes for general engineering purposes. Two illuminated displays on Stand D.618 will show tubes representative of the range. Small cut lengths of circular section or special extruded shapes, including precision rectangular waveguides, will be the subject of another display. For the manufacture of these items the Company enjoys a high reputation with the manufacturing jewellery, optical and instrument, electrical, plumbing and hardware trades.

Tubes will also be exhibited by some of the firms referred to in the "Non-Ferrous Metals" section.

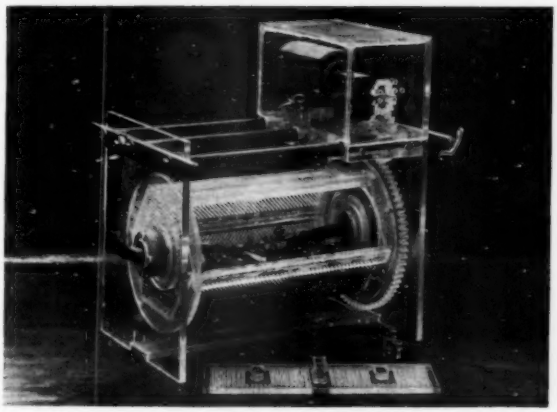
Wire

THE LONDON ELECTRIC WIRE CO. AND SMITHS, LTD., and its associates, FREDERICK SMITH AND CO., THE LIVERPOOL ELECTRIC CABLE CO., LTD., and VACTITE WIRE CO., LTD., will again occupy Stand C.717, and their exhibit will comprise a comprehensive display of bare and insulated electrical conductors. These will include the well-known Lewcos products—cotton, silk, paper, enamel, Lewmex, Lewmexglas, and Lewbestos insulated wires and strips; insulated resistance wires; Glazite connecting wires and copper braids and cords; Anacos bare copper and copper alloy wires, strips, strands, sections and forgings; telegraph and telephone line wires, trolley and contact wires and overhead power transmission wires; aerial wire and earth rods; L.E.C. rubber, thermoplastic, paper and cambric insulated cables; underground power cables, house wiring and domestic cables and flexibles; Vacrom and Eureka resistance wires and tapes, molybdenum rods, wires and tapes and special wires for the electric lamp and radio valve industries.

On Stand D.607, JOHN RIGBY & SONS, LTD., will put on a display of steel wire, ranging from $\frac{9}{16}$ in. diameter down to 0·004 in. diameter, in both coils and lengths, in all finishes, and for all trades. A speciality which will be particularly emphasised will be their precision drawn pinion rod and sections in steel, brass and nickel silver for use in precision instruments and in mechanisms for meters, clocks, toys, etc. Reference is made elsewhere to their powder metallurgy products.

The emphasis in the steel ropes section of Stand D.411 (WRIGHTS' ROPES, LTD.), will be on the diverse types available to-day. The exhibits in this section will include winding ropes, locked-coil aerial ropes and ropes made for special purposes, whilst in the fibre rope section metallurgical interest will centre chiefly on the drop stamp ropes. On the same stand, THE ROLLASON WIRE CO., LTD., will have on show a selection from their comprehensive range of alloy and high strain steel wires as used by the motor, cycle, bedding, seating and engineering industries.

Other firms displaying wire and wire products will include LEE OF SHEFFIELD, LTD. (D.530), who will be showing high-grade steel wire and stainless steel wire; PADLEY & VENABLES, LTD. (D.525/422), stainless steel wire; RICHARD JOHNSON & NEPHEW, LTD. (B.417/322), ferrous and non-ferrous wires; THE LOCKER GROUP (D.511/408), woven wire and wirework; RYLANDS BROS., LTD. (D.538/639), bright, annealed, coppered, galvanised and tinned steel wires, fencing, welding wires, nails and various wire products; and THE WHITECROSS CO., LTD. (D.621), whose display will include similar items together with copper wire, rolled steel strip, and ropes for mining, shipping and engineering purposes. Reference will also be made to the part which Whitecross ropes played in the salvaging of the *Empress of Canada* at the Gladstone Dock, Liverpool.



Courtesy of Electrochemical Engineering Co., Ltd.

PX 12 Efco-Udylite Perspex plating barrel.

Electroplating

The exhibits by FESCOL, LTD., will emphasise the wide range of capacity of their plants for carrying out the Fescolising process, and will show its value in renewing worn parts and prolonging the life of new components from the points of view of both wear and corrosion. The front of Stand D.529 will be occupied by a large drying cylinder (4 ft. diameter × 11 ft. 3 in. long), Fescolised in nickel to prevent corrosion and thus avoid staining of the paper passing over the cylinder. At the other end of the size range, there will be two small rolls ($\frac{1}{2}$ in. diameter × $4\frac{3}{4}$ in. long) Fescolised in chromium. As a background, a display of photographs of work treated, on three large panels, will indicate the wide range of applications of the process.

There will be a working demonstration on Stand C.609 (ELECTROCHEMICAL ENGINEERING CO., LTD.) of Zero-Mist, a material which, when added to existing chromium plating baths, completely eliminates spray and the necessity for fume exhaustion, and cuts drag-out losses by reducing surface tension. It is completely stable and has no deleterious effects on chromium plating. The plant side will be represented by Efco-Udylite Perspex plating barrels and a continuous dryer for barrel-plated parts. The Perspex plating barrel has been developed to meet the need for a fully immersed plating barrel suitable for a variety of processes, without the necessity of transferring work from one container to another at any stage during the pre-cleaning and plating processes. The average weight of work that can be processed in one batch is 15 lb. and the whole unit weighs 39 lb. unloaded, so that the barrel can be transferred single-handed.

During the past year, R. CRUIKSHANK, LTD., have redesigned many of their standard plant items, to give a more efficient and better finished product, and these will form the main part of the display on Stand D.226. They include the two senior plating barrels, the 1B and 2B centrifuges and the junior plater. The new Pureflow all-steel filter unit will also be shown together with a standard type filter press, thus covering all types of filtration required in a normal plating shop. The multi-oblique plating barrel with four baskets shown

Courtesy of Metallisation, Ltd.

Mark 16 hard-facing attachment.

last year, and which has proved most successful for small batch plating jobs, will again be on view. Other items will include a new type rumbling barrel and the usual range of polishing mops, compositions, brushes, etc.

Featured on the stand of SILVERCROWN, LTD., (C.221) will be a range of tilting-type plating barrels. The Magna has a capacity of some 2–3 gallons of articles, the Demi, ½–1 gallon, and the Mini, 1–2 pints. One of the main features of the Magna is the hydraulic speed damper control, which ensures perfect safety for the operator when emptying, as the barrel can only proceed to its lowest position at a speed predetermined by the damper valve. There will also be exhibited a totally immersed plating barrel for bulk barrel plating, a multi-cascade rumbling barrel, a centrifugal dryer, filter plant, polishing mops, compositions, etc. A wide range of resistance boards and control gear will also be shown, including units with the electrical mechanism immersed in switchgear oil to obviate corrosion attack.

A live demonstration of the Dalic plating process will be a prominent feature of the display of the rectifier section of WESTINGHOUSE BRAKE & SIGNAL CO., LTD. (Stand C.508, and Outdoor 1341/1240). One of the well-known plating equipments will also be shown, together with a photographic display of an installation of Westalite oil-immersed heavy current rectifiers used in the production of hydrochloric acid.

No details are yet to hand of the exhibits on the stands of W. CANNING & CO., LTD. (D.207/108 and D.209/110), makers of electroplating equipment.

Specialised equipment applicable in electroplating because of the corrosive or toxic nature of the materials used will be shown on the stands of PRODORITE, LTD. (D.431), BRITISH LABOUR PUMP CO., LTD. (D.339), BAKELITE, LTD. (C.404), and WYNN (VALVES), LTD. (D.747), further details being given under the heading of "Miscellaneous."

Other Surface Treatments

The use of metal spraying for building up worn parts, and for the recovery of parts that have machining errors, is now standard practice. Among the exhibits of metal spraying equipment on Stand Outdoor 1348, METALLISATION, LTD., will be showing a new lighting device for automatic metal spraying machines, which will demonstrate the ease with which multi-nozzles may be lit. In addition, a new process of hardfacing—a combination of metal spraying and welding—will be demonstrated: it will be of considerable interest to engineers with problems of intense wear or corrosion, or a combination of both. The material is sprayed with a Mark 16 spraying pistol, using a special attachment which increases its scope at little extra cost.

Stand D.402 (DELORO STELLITE, LTD.) will show many applications of Stellite in industry, and there will be in operation a complete hardfacing bench, such as is used regularly in the works. Experts will be available throughout the Fair to discuss hardfacing problems.

Examples of architectural ironwork, rust-proofed by the sherardizing process (coating with zinc by heating in zinc powder) will be displayed on Stand B.726 by the ZINC ALLOY RUST-PROOFING CO., LTD. The Company does not manufacture architectural ironwork but specialises in carrying out sherardizing for the makers of casements, metal trim, screws, nails, etc. The stand will form a technical information bureau where visitors will be able to obtain full particulars of the process, its cost, and details of the uses to which it can be put in various trades.

Danelle, a new hard surfacing alloy made by DANITE HARD METALS, LTD., will be featured on Stand D.349/244. It is supplied as complete castings, or as rod for deposition by welding. The abrasion resistance of this new alloy, which is slightly harder than tool steel and retains its hardness at elevated temperatures, is attributed to its low coefficient of friction. The deposition of Danelle on the teeth of a 6 ft. diameter steelworks hot saw increased its life from 400 tons with 4 in. off the blade diameter to 1,200 tons with only ⅛ in. off. Other applications include excavator teeth and bucket edges, pug mill blades, rolling mill guides, and mixer paddles, etc.

On Stand D.754, ROTO-FINISH, LTD., will be showing two new types of machine for deburring, polishing, radiusing, etc. These two machines have been primarily designed for small batches of precision components. The DW. 12-32-1 has been developed from a machine used originally for laboratory testing, but especially designed to fulfil the same conditions as prevail in larger machines. The barrel capacity is 30–50 lb. of precision components plus processing chips and compounds in

Courtesy of Deloro Stellite, Ltd.

Demonstrating hard-facing by the oxy-acetylene deposition of Stellite.

solution. The DW. 16-16-2 (or Midget) has been specially designed to meet the exacting requirements of those industries which produce valuable and very small machined components, including jewellery and watchmaking parts. Due to a system of overlapping chutes, no valuable or minute parts are scattered, damaged, or lost during the separation from the chip mass after the completion of the deburring or fine polishing run. A complete range of components showing the effectiveness of the process will also be on show.

JENOLITE, LTD., will be showing on Stand B.221 a range of industrial chemical specialities for the pre-treatment of metals. The rust remover and neutraliser (RRN), applied by immersion, spray or brush, simultaneously removes rust and phosphates, thus providing a suitable base for painting. To overcome the difficulty of rain tending to weaken outdoor phosphate coatings of this type before painting, a chemical sealer has been developed for application while the treated surface is still damp. Other exhibits will include a paint stripper particularly suitable for removing synthetic enamel and cellulose, and a solution for etching the surface of aluminium prior to painting.

Processes for finishing, colouring and protecting metal components will be featured by METAL PROCESSES, LTD., on Stand D.229. A long row of tanks, heated by gas rail burners and containing all their various dipping solutions, will be available so that visitors can carry out sample immersions of small metal plaques, with the help of the firm's demonstrators. The principal exhibit will be the chassis of one of the famous Cooper racing cars, which are treated by the Deruster process. Exhibits displayed in glass cases will range from parts of a steel girder down to the small parts of clocks and watches, from a bicycle pump to a small zip fastener, and from a steel spring to a small electrical appliance.

Plus Gas Formula A, to be shown on Stand D.129 by PLUS GAS CO., LTD., is a chemical substance primarily designed for dismantling corroded machinery of all types. It is extremely penetrative and, by removing the

Courtesy of Roto-Finish, Ltd.

DW 16-6-2 (Midget) machine for deburring, polishing, radiusing, etc., of very small machined components.

Courtesy of Alfred Bullows & Sons, Ltd.

9 cu. ft./min. Hydrovane rotary compressor mounted on horizontal air receiver.

water content, it leaves the rust in the form of an oxide. It is not a rust solvent, and if used for the removal of surface rust, it must be followed by brushing. It is useful for removing rust from nickel or chromium plating, and can be used with all non-ferrous as well as ferrous metals. It is non-acid and non-corrosive. Plus Gas Formula B, also to be shown, is a resin-based fluid designed to give protection against corrosion. The coating produced is of a transparent nature, and its elasticity enables it to expand and contract with the metal. It has no detrimental effect on lubricating oil, and it can be applied over oil-bound or lead-base paint to give it longer life.

Many anti-rust products will be shown by FLETCHER MILLER, LTD., on Stand D.510—oils for preventing rust, typified by the various Rodol liquid and solid grades; Severine for removing rust; and Flick, an oil for releasing rust-seized metal parts. Grease removal will also receive special attention in exhibits of Solvex crystals for hot water degreasing, and Liquid Solvex for cold water cleaning of metals.

The main property of Metacon 516, which will be featured by CRODA, LTD., on Stand D.220, is that of a rust remover. At the same time, material treated with it is rendered anti-corrosive for a fair period, and far more resistant to corrosion than the original rust-free surface. Furthermore, the surface is rendered particularly suitable for painting and finishing generally. Metacon 516 is also available in jelly form, which is particularly suitable for treating difficult vertical surfaces. The other main exhibit on the stand will be Crocell strippable plastic coating. Components can be covered with a tough thick thermoplastic skin, which protects against corrosion and mechanical damage during storage and transit, by dipping in hot Crocell.

The paints and protective finishes shown on the stand of CELLON, LTD. (B.527) will include types suitable for use on metal, in air-dried or stoved, sprayed or dipped, hot or cold formulations based on the latest epoxy and vinyl resins. These will be put forward as answers to the attacks by corrosive chemicals, solvents, detergents and humidity for such articles as washing machines, refrigerators, water heaters, etc. Anti-corrosive primers

Courtesy of Colour Sprays, Ltd.

Small paint spraying outfit.

will also be featured, including Celletch self-etching primers for light alloys.

A composite exhibit of the Hydrovane compressors will be staged by the British licensees ALFRED BULLOWS & SONS, LTD., BURTONWOOD ENGINEERING CO., LTD., and THE HYMATIC ENGINEERING CO., LTD., on Stands D.743/642 and Outdoor 1354. On the indoor stand, Bullows will have two new items of special interest on show. The Bullows-Binks Model 19 spray gun, a new high performance spray, is the first result of a manufacturing agreement between Bullows and The Binks Manufacturing Co. of Chicago, whilst the Bullows-Berridge rotating spindle automatic spray painting machine is the result of collaboration with Berridge Aircraft, Ltd. The latter is a simple versatile machine for high speed automatic painting of near circular sections up to 12 in. diameter. The standard range of Bullows spray painting equipment will also be on view, together with a working water-wash spray booth.

A full range of spray guns, pressure feed containers, air rectifiers and accessories will be shown on Stand D.734 by AEROSPRAY, LTD., along with portable and stationary air compressor sets. A new spray gun, Type G.12, designed for rapid and even coating of large surfaces, will produce a spray width up to 30 in. when supplied from a pressure feed container. Automatic spray guns and sensitive fluid pressure regulators for use with the Ransburg electrostatic spray painting process will also be displayed, along with an air-operated barrel pump for heavy materials such as bitumen compounds, sound deadeners, etc., and spray guns for the application of such materials.

THE MIDLAND FAN CO., LTD., will be sharing Stand A.622 with its associated company B.I.F. ENGINEERING CO. (1940), LTD., and will be showing a range of paint spraying equipment, including compressor sets, pressure pots, spray guns and air filters and reducing valves. Of special interest will be a new 4 ft. wide water-wash bench-type spray booth. Other exhibits will include paddle blade centrifugal fans (in PVC and mild steel), propeller fans, and high pressure blower fans.

Spraying equipment and air compressor plant will also be featured on Stand D.600 by COLOUR SPRAYS, LTD., the range extending from the small artists air brush to the large industrial spray guns. There will also be displayed special types for operations such as silvering on glass and plastics, striping, and a kind of lining work. Among the accessories will be air line filters, pressure reducing valves and a typical spray booth unit. Improvements have been made to the low pressure spraying outfit shown last year and its weight has been reduced without sacrificing its sturdiness.

No details are yet to hand of the exhibits on the stand of FLAME HARDENERS, LTD. (D.131), makers of surface hardening equipment.

Furnaces and Refractories

THE GAS COUNCIL exhibit on Stand C.641/540 will stress the breadth and extent of the services which the industry can offer to users. Side by side with this, there will be shown examples of the newest developments in the design of industrial gas appliances. A further section of the stand will be devoted to demonstrations of how improvements in fuel economy and efficiency can be brought about by good design. There will be three specific demonstrations illustrating this point, devoted respectively to the advantages of insulating refractories; the importance of sound burner design and insulation in tank heating; and of pressure control in larger furnaces, particularly those in which the door has to be opened frequently to insert the work. Among the new developments to be shown will be a furnace working at temperatures up to 2,000° C.; a portable mould dryer; a small high temperature furnace working up to 1,400° C.; a small ceramic kiln; and a heat treatment furnace. In addition, there will be shown in operation a range of precision burners made by various manufacturers.

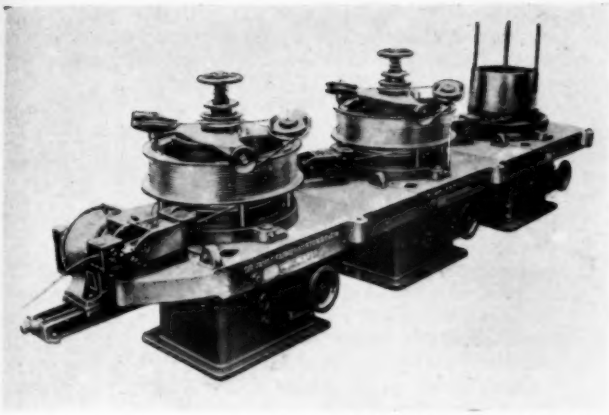
The exhibits on Stand C.411/310 will be drawn from both the furnace and the instrument side of the activities of INTEGRA, LEEDS AND NORTHRUP, LTD. The furnace exhibits will comprise a Homocarb gas carburising furnace, a Homo steam tempering furnace, and the Vapocarb Hump hardening furnace, together with all auxiliary and control equipment. The instrument exhibits will be dealt with in the next section.

On the ALFRED HERBERT stand (D.321) there will be an Aritor Dryer Pulveriser, which has been used all over the world for firing boilers, metallurgical furnaces and kilns. It also has a wide application in grinding and drying other materials, its great advantage being that it can deal with wet materials without the aid of external dryers.

FOLLSAIN-WYCLIFFE FOUNDRIES, LTD., on Stand D.709, will be exhibiting carburising boxes, pyrometer sheaths, cyanide pots and other furnace parts in E.V. heat resisting steel, in Wynite heat resisting cast iron, or in Penetral-treated mild steel.

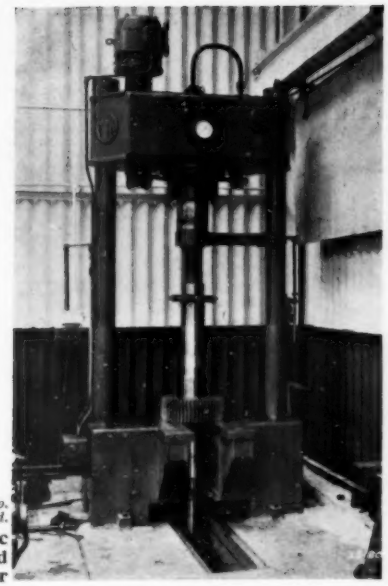
Courtesy of Ether, Ltd.

The Thermal-trol electronically operated temperature controller.



Courtesy of Sir James Farmer Norton & Co., Ltd.

Differential concentric block non-slip wire-drawing machine.



Courtesy of John Mills & Co. (Llanidloes), Ltd.

100-ton Oilaulic forcing press used for assembly of gear and shaft.

Temperature Measurement and Control

Stand C.700 (ETHER, LTD.) will again house a full range of temperature indicators, recorders and controllers, many of them based on electronic principles. The Thermal-trol electronically operated temperature controller, utilising the Wheatstone Bridge principle, will be on show for the first time, and other instruments featured will include the Wide-Strip electronically operated potentiometer recorder, and the Ether-Wheelco Type 221 Capacitrol controller. A range of solenoid and diaphragm operated control valves for use with oil, steam, gas, air or water will be displayed, together with 3-way valves for pneumatic control work. The exhibits will also include surface contact pyrometers, molten metal pyrometers, optical pyrometers, radiation tubes, and thermocouples.

As mentioned in the previous section, part of Stand C.411/310 (INTEGRA, LEEDS AND NORTHRUP, LTD.) will accommodate temperature measuring and controlling instruments. Two instrument panels will contain representative examples of the Micromax Model S strip-chart recorders and recording controllers; the Micromax Model R circular-chart recorders and recording controllers; the Micromax Model C indicating controller; and various examples of portable and switchboard manually operated potentiometer indicators. Also on show will be examples of thermocouples, protection tubes, wells, etc., and accessory items for their use.

On Stand C.734, THE INDUSTRIAL PYROMETER CO., LTD., will be exhibiting indicating, recording and controlling pyrometers, including multi-point models; special pyrometers for molten metal and surface contact temperature measurements; and thermocouples and accessories for all applications. Various types of control accessories for use with electricity, gas and oil will be shown by the associated companies: H. J. S. INDUSTRIAL INSTRUMENTS, LTD.; INDUSTRIAL CONTROL VALVES, LTD.; and NOTTINGHAM THERMOMETER CO., LTD. Of special interest will be a demonstration of a simple and inexpensive equipment for the control of small gas-fired plant. It comprises a gas governor with vernier adjustment; a water column gauge to measure the governed outlet gas pressure; and a 4 in. indicator to show the temperature of the plant.

Included in the display of wires and cables on Stand C.720 (PYROTENAX, LTD.) will be found examples of thermo-electric cables.

Machine Tools

Although that section of the machine tool trade concerned with cutting operations will not be represented at the Fair, there will be exhibits of interest to those engaged in the cold working of metals and alloys. New designs of wire-drawing machinery will be shown on Stand D.167 by SIR JAMES FARMER NORTON & CO., LTD., and will include a concentric differential block representing a departure from their usual designs. The main features include non-slip unit formation; higher production speeds; straight line drawing; elimination of twist between blocks; and increased safety factor at high speeds. The time to strip a new design of block to be shown is a matter of seconds only, and this will increase efficiency by 10% when used as a finishing block, and by 40% when used as a single holer. Also shown for the first time will be a revolutionary design of non-slip machine for drawing extremely fine wire. Rotary swaging machines will be representated by a rotary spindle two-die type and an inverted stationary spindle four-die type which has proved popular for tube swaging. On the same stand, the associated companies, ANGLARDIA, LTD., and WIRE DRAWING DIES (MANCHESTER), LTD., will display diamond dies and tungsten carbide die pellets, dies, and other products. Shaped dies with new profiles enabling bright drawn finished bar to be produced in one pass from the black bar stock will be a prominent feature.

Many of the products of TURNER BROTHERS (BIRMINGHAM), LTD., such as press tools, jigs and fixtures, are made to individual requirements so that they are not available for exhibition, but they will be represented on Stand D.512 by a display of pressings, mouldings and die castings made by them. The company also manufactures power presses ranging from 6 to 70 tons capacity and has recently developed a tangent bending machine for use in the streamlining of such products as refrigerator cabinets. Some examples of the power presses will be

Courtesy of Hordern, Mason & Edwards, Ltd.

Model 14 T.D.P. toggle-action drawing press.

on view, together with the Turner Brothers' saw tooth notching machine, and possibly a model of the tangent bending machine.

The smallest of a range of coining presses will be shown by TAYLOR & CHALLEN, LTD., on Stand D.415. Its capacity is 150 coins per minute—up to $\frac{3}{4}$ in. diameter in bronze and $\frac{7}{8}$ in. in silver. The press is driven by a 4 h.p. motor and controlled by a key clutch, and a device is fitted to stop it imediately if no coin is fed between the dies. Another device stops it if the coin is not properly removed from the die. Other exhibits will include a double action drawing press, tooled up for making a stewpan lid, and a Type 1468 notching press. The latter is designed expressly for notching freewheel or chainwheel sprockets of sizes varying from $2\frac{1}{4}$ in. to 10 in. in diameter. The dividing wheel is easily changed, being situated under the saddle, and the other adjustments needed for notching different diameters of sprockets with different numbers of teeth are quick and simple.

From the range of Oilaulic presses made by JOHN MILLS & Co. (LLANIDLOES), LTD., five have been selected for showing on Stand D.337. They are: a 3-ton bench press, ideal for innumerable applications in the fitting shop; a 15-ton standard vertical press fitted with a new lightweight type of straightening equipment which makes for easier handling; a 45-ton closed frame press used extensively on heavy marking, coining, flattening and squeeze-riveting operations; a 60-ton horizontal press designed for on-the-spot bending and straightening of rails and heavy sections; and a 100-ton forcing press used for a variety of assembly operations.

The accent this year on Stand D.241 will be on the Greer-Mercier hydro-pneumatic accumulator, made under licence by FINNEY PRESSES, LTD. Two working applications will be shown—one in the new Finney portable hydraulic power pack, and the other as a pulsation dampener or shock absorber in hydraulic systems. Also on view will be the new relaying pump unit specially designed for use with the power pack together with the latest models of the Finney range of presses for the plastics, rubber and engineering industries.

HORDERN, MASON & EDWARDS, LTD., will be exhibiting eight power presses on Stand D.603/502. Five of them will be the open front type, ranging in capacity from 12 to 100 tons pressure, and one of them, an inclinable 40-ton machine, will be fitted with automatic roll feed mechanism. Double sided presses will be represented by the sturdy double-crank variable stroke model D.C.P.5, rated at 150 tons and used in the automobile, aircraft and allied industries; the single crank fixed stroke model C. 28—a 200-ton press for general blanking, piercing, raising, forming, etc.; and a toggle action drawing press, Model 14 T.D.P., a machine of advanced design incorporating a highly efficient worm drive. All machines exhibited will be under power and in actual production of various components.

The $7\frac{1}{2}$-ton Hare hydraulic power press to be shown by DOWDING & DOLL, LTD., on Stand D.537/434 is of compact design and rigid construction, being fabricated from heavy steel plate. The cylinder head, ram and valve blocks are machined from steel billets, and sensitive easy control is by hand or foot lever.

On the stand of SCOTTISH MACHINE TOOL CORPORATION, LTD. (D.313), CRAIG AND DONALD, LTD., will be showing a 100-ton press, width between sides $16\frac{1}{2}$ in., whilst JAMES BENNIE & SONS, LTD., will have on view a punching, cropping and shearing machine.

The experience of HUMPHRIS & SONS, LTD., in the manufacture and use of power presses has been invaluable in the design of feeding and handling equipment, and on Stand D.760 there will be examples of both types of equipment. The most recently designed power press in the Humphris range, the Pressmaster 10, rated at 10 tons, will be exhibited along with a 20-ton inclinable roll feed press; a 10-ton endwheel dial feed press; and a 10-ton double roll feed press. The handling equipment to be seen on this stand will comprise an inclinable self-centring coil stand, representative of a new range of coil handling equipment: and a combination decoiler

Courtesy of Rockwell Machine Tool Co., Ltd.

Cycling feed equipment for presswork.

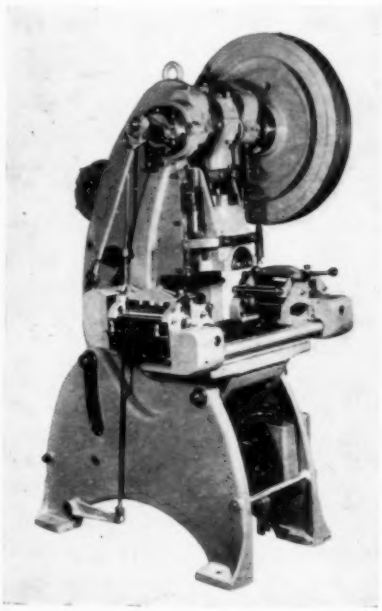
for handling coils up to 1,000 lb. in weight and 16 in. in width.

An interesting set-up on Stand D.224 (ROCKWELL MACHINE TOOL CO., LTD.), will be a 12½-ton unit press with a slide feed, straightener, automatic uncoiling equipment, stock oiler and wiper, and a scrap cutter of the latest design. There will also be power operated stock straighteners and a new type of straightener, primarily designed for coiled tubing or bar, in which two sets of seven V-grooved rollers are used. An entirely new type of feeding equipment should prove of special interest. It is known as the "cycling feed." When particularly long lengths are required, which are outside the range of the pitch capacity of the type of feed used, an electrical counter will allow a pre-set number of strokes of the feeder before the press is energised.

J. P. UDAL, LTD., will be showing new developments this year. On Stand D.606 an automatic transfer feed will be shown under working conditions, feeding at a rate of approximately 50 pieces per minute, whilst a gripper-type unloader will be removing pressings from the lower die at the back of the press. An automatic rising-screen type guard will be shown on the front of the press, this arrangement giving maximum production rates with a high safety factor. The well-known Fastrip type guard for power presses will also be shown incorporating an arrestor mechanism to give early guard opening, this again giving high production rates with a high safety factor.

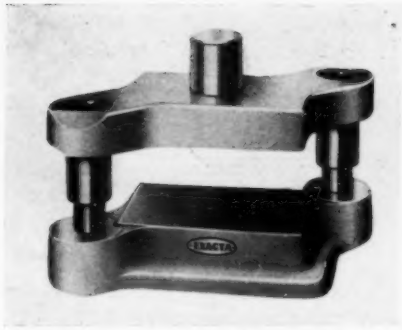
For many years COLEY BROS. (TOOLS), LTD., have specialised in the manufacture of Exacta standardised press tool die sets and precision components, and the exhibits on Stand C.315 will include interesting examples of high class press tools mounted on Exacta die sets; Exacta patented linear motion ball bushes; and Steadfast universal machine clamps. In addition there will be details of services available to supplement the capacity of tool making firms, including flame cutting of blanks, heat treatment, and precision machining.

A photo-electric safety device will be demonstrated



Courtesy of Humphris & Sons, Ltd.

Model IC.20/F roll feed press.



Courtesy of Coley Bros. (Tools), Ltd.

Type DPL press tool die set.

on a press brake by PRESS GUARDS, LTD., on Stand D.601. In the event of any interruption of the light beam, whilst it is descending, the slide is brought to rest. A brake arrestor device will be shown on a power press: used in conjunction with an interlocking type guard, it is designed to arrest the movement of the crankshaft in the event of an uncovenanted stroke. Guards for grinding machines, hand presses, drilling machines and milling machines will also be displayed.

A slidestop guard for fly-presses shown a year ago by INDUSTRIAL GUARDING EQUIPMENT, LTD., was only suitable for very light presses, but a more robust model will be shown this year on Stand D.707. During the last year, an efficient guard has been produced for die casting machines, and this also will be on view. Other equipment on this stand will include a Pneumaster press brake guard; a Controlock guard developed for small hydraulic and pneumatic presses; a Superlock guard for power presses; industrial wirework; and protective footwear.

In the automatic spring coiling machines to be shown by BENNETT TOOLS, LTD., on Stand D.705, no special cams are necessary for the many designs of springs, and the ease and speed of adjustment of the cams enable the machines to deal with the production of relatively small quantities in an economic manner. Much thought has been given to the reduction of maintenance costs, and ball and self-lubricating bearings are used to an increasing extent.

JOSEPH RHODES & SONS, LTD., will be showing, on Stand D.325, a large "fluid-driven" guillotine shear to cut 10 ft. × ⅝ in. steel plate; a double action drawing press, with fluid-controlled outer ram (displacing the usual toggles, links, etc.); and an "anti-deflection" press—inclinable type—fitted with Simplex deep drawing device.

A 90-ton press brake and a 4-roll bending machine will be prominent features of Stand D.236 (BRONX ENGINEERING CO., LTD.). The latter is capable of bending ¼ in. mild steel plate up to 10 ft. wide. The machine is of heavy fabricated construction and the rolls are machined from forgings in 0·5% carbon steel. All the rolls are 9 in. diameter; the top and bottom ones are positively driven and the two side bending rolls are idle. The press brake has capacity for bending ⅜ in. mild steel plate × 8 ft. wide between the housing, and 10 s.w.g. × 10 ft. overall the beams.

In the range of tube bending machinery on the stand of HILMOR, LTD. (D.147), the motorised non-mandrel bender Type H.M.4/B will be shown for the first time.

Courtesy of W. & T. Avery, Ltd.

No. 6406 visual hardness testing machine.

This machine incorporates the Hilmor patent pressure indicator, which, by determining the exact degree of bending pressure to be applied to the tube, automatically ensures the best possible setting to counteract flattening, rippling or throating of the tube. Demonstrations will be given of this machine, together with hand-operated and motorised mandrel type machines for the production of full bore bends on extra short radii.

The machines exhibited by THE MIDLAND SAW & TOOL CO., LTD., on Stand B.228 will all be available for demonstration. Two—the Major/ATC toolroom bandsaw machine with butt welder for saws up to $\frac{5}{8}$ in. incorporated ; and the 16 in. toolroom bandsaw machine —are new models. The latter can also be supplied for cutting non-ferrous metals and for cutting sheet metal. The other metal cutting exhibits will include the AT toolroom bandsaw machine with saw brazer incorporated ; a Hyspeed bandsaw machine for cutting sheet metal ; an overhead cut-off machine for extruded aluminium sections ; an electric butt-welding unit for saws up to 1 in. wide ; and an eight-speed bandsaw machine with automatic moving table. The last-named has been ordered by a well-known internal combustion engine maker, and one of its jobs will be the sectioning of cylinder blocks for inspection.

A comprehensive range of hard edge flexible back bandsaw blading suitable for ferrous and non-ferrous metals will be shown by HIGH DUTY SAWS, LTD., on Stand B.228.

Small Tools and Tool Steels

The major part of Stand D.234 (RICHARD W. CARR & CO., LTD.) will be devoted to a display of a range of Motor Brand fine tool steels shown in the form of finished tools loaned by customers. The steels illustrated by these tools are suitable for plastic moulding, die-casting, hot extrusion, impact extrusion, punching, pressing, clipping, drawing, thread rolling, and for production tools such as gauges, collets, taps, drills, cutters, reamers, hobs, etc. There will also be a selection of Motor Brand engineers' small tools, while a further section of the stand will be used to illustrate the type of work carried out at the Company's Birmingham Heat Treatment Department.

A section of the DELORO STELLITE stand (D.402) will be devoted to a range of tipped and solid tools, milling blades, centres, workrests and cutters. Several examples of special tools and unusual tooling applications have been collected and demonstrations will be given throughout the day of the Stellite hard steel drill.

Tool steels have always been one of the major products of TURTON BROTHERS & MATTHEWS, LTD. and this will be reflected in the exhibits on Stand D.413. Flyco Brand high speed steel twist drills, reamers and milling cutters will be on show whilst engineers from metal working plants will be interested in the display of shear blades for hot and cold cutting, and in the working model of a hot blooming mill and shears. Other exhibits will include a range of butt-welded tools, heavy coil springs, and Torpedo permanent magnets.

Magnetic devices will be featured on one side of Stand D.417/316 (JAMES NEILL & CO. (SHEFFIELD), LTD.), where the principal display will be of Eclipse permanent magnetic chucks. Eclipse magnetic adjustable links will also be introduced as an aid to production. By a simple adjustment of wing nuts, this tool is capable of providing two magnetic faces for holding sheet at any angle.

Other stands on which exhibits in this group will be displayed include D.218 (ALFRED HERBERT, LTD.)—Coventry, Tangie, Tangel and Tangar dieheads, dies and chasers ; Ardoloy tools and cutters ; Hypercut butt-welded lathe and planer tools ; Coventry chucks ; Herbert ground thread taps and rolling dies ; drill chucks ; and Saftork tappers, etc. On Stand D.113, LENCHS (BIRMINGHAM), LTD., will be showing press tools, jigs, fixtures, special purpose machines, special cutters and reamers and cemented carbide tools and tips ; whilst silver steel and tool steels will be among the exhibits on Stand D.424 (PETER STUBS, LTD.).

Mechanical Testing Equipment

A range of testing machines will be shown by SAML. DENISON & SON, LTD., on Stand D.517. It will include

Courtesy of G.W.B. Furnaces, Ltd.

Powermaster oil-fired boiler.

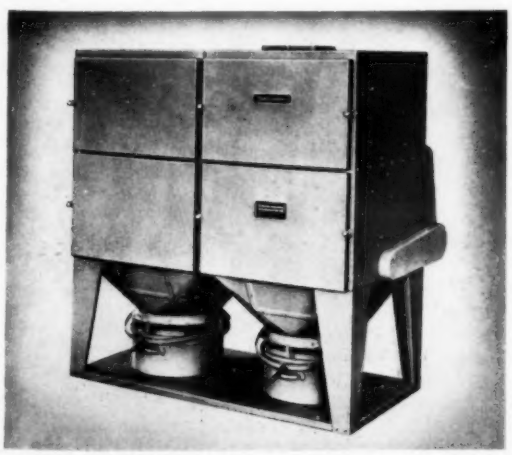
a T42.A3/10/15 ton universal testing machine; a T42.B3 30/50 ton universal testing machine; tensile and universal testing machines of 5·5/6·7 tons capacity (T42 and T42U); a T47 miniature high temperature creep testing machine; and a new heavy duty torsion testing machine. In the models T42.A3 and T42.B3 universal testing machines, which are greatly improved versions of earlier machines, the method of load measurement remains on the compound weighing lever principle, although the load is applied hydraulically. Both machines are equally suitable for production and highly accurate research work. The heavy-duty torsion tester is a completely new product.

The new 6105 CCG tensile testing machine to be shown on Stand D.523/420 by W. & T. AVERY, LTD., has been designed for precision testing up to 2,500 lb. It can be used for materials ranging from metallic wire or strip to plastics, textiles and cement. Strain is applied by hand-operated worm and screw gearing and the load is indicated on a clearly graduated chart. A recording device can be fitted where autographic load-extension curves are required. The three ranges cover $\frac{1}{3}$, $\frac{1}{2}$, and full capacity. The visual hardness testing machine No. 6406 is equipped for both Brinell and diamond pyramid testing. A built in microscope and an arrangement which projects the enlarged image of the impression on to a ground glass screen, makes the apparatus ideal for rapid repetition testing.

The testing machines to be seen on Stand D.632 (GEORGE H. ALEXANDER MACHINERY, LTD.) will include a Rockwell hardness tester incorporating the latest designs for simple and convenient operation and an Alexander sheet metal testing machine with a new range of auxiliary tools for deep drawing tests.

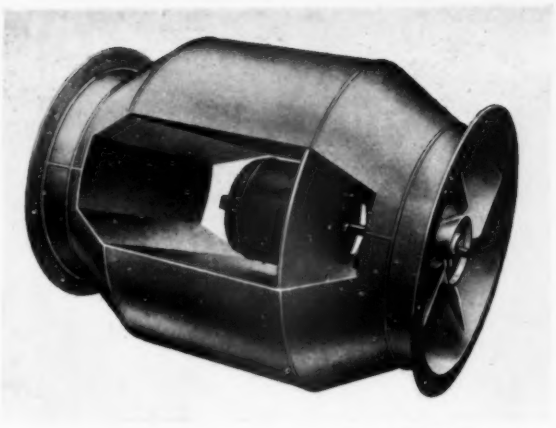
Electrical Equipment

The fusegear shown on the ENGLISH ELECTRIC stand (C.510) will include a flush type fuse switchboard; Superform distribution boards and isolators; an overhead busbar system; a display of cartridge fuses; sub-station equipment; and industrial fuseboards and combination fuseboards; whilst switchgear will be represented by a 400V 25MA switchboard incorporating air circuit breakers of 1,600 amp. and 600 amp. capacities.



Courtesy of Dallow Lambert & Co., Ltd.

DM 100 series, type 201 Dustmaster fitted with auto-shaker.



Courtesy of Keith Blackman, Ltd.

Tornado 10-in. bifurcated fan of the high temperature type.

Five typical industrial motors will be exhibited: a flange-mounted geared motor unit; a chemical works motor; a foot mounting motor; a crane motor; and a Buxton-certified flame-proof motor. There will also be displayed a number of fractional horsepower motors and a selection of instruments.

Stand C.503/402 will show examples of GENERAL ELECTRIC contributions to marine engineering, although many of the items selected are of wider industrial application. Auxiliary electrical power for ships will be represented by a 550kW turbo-generator set, and by marine motors. Main and group switchboards will show typical layouts of fully enclosed and protected air break switchgear in cubicle type boards. Other items will include galley ranges; stewards luminous call and fire alarm equipment; fans; and wires and cables. The lounge section of the stand will be furnished so as to show fans, telephones, and lighting fittings in a natural ship's setting.

Oils

Prominently featured on the stand of FLETCHER MILLER, LTD. (D.510) will be the cutting fluid range which covers the servicing of all metal cutting operations, whilst for machine tool lubrication there will be Veta, Gena and Almarine oils and greases. Drawing lubricants will be included in the exhibits, along with materials for heat treatment, including surface hardening powder, box carburiser, and a range of Almarine quenching and tempering oils. Attention will be drawn to metal pre-treatment by a display of degreasers, rust removers, and rust preventatives.

D.317/214, the stand of SHELL-MEX AND B.P., LTD., distributors for the Shell and Anglo-Iranian oil groups, is mainly designed as a meeting place for visitors and friends of the company, and for the discussion of problems involving lubricants or fuels.

The exhibits on Stand D.534 (GULF OIL (GREAT BRITAIN), LTD.) will cover the complete range of lubricating oils, insulating oils, cutting and drawing oils, and anti-rust products. There will be a wide range of metal working lubricants for ferrous and non-ferrous applications, and Drawing Oil RB.2/45, developed recently for the drawing of light alloy tubes, will be of

Courtesy of The Wellman Smith Owen Engineering Corporation, Ltd.

Ross valve unit for synchronising a number of operations on a non-ferrous strip recoiler.

special interest. Technical staff will be in attendance to advise on lubrication problems.

MANCHESTER OIL REFINERY (SALES), LTD. will be featuring on Stand D.333/230 their range of sulpho-chlorinated cutting oils. One of them has been found particularly successful for the difficult operation of broaching titanium alloys. Other cutting oils suitable for use when machining austenitic steels and the Nimonic alloys will also be shown. In addition, there will be a full range of M.O.R. highly refined industrial oils and petroleum derived chemicals.

Miscellaneous

The fire fighting and fire detecting equipment displayed by THE PYRENE CO., LTD., on Stand D.634 will include a recent development which has proved highly effective against fire outbreaks involving such metals as sodium, calcium, magnesium and aluminium. The extinguishing agent used is Pyromet dry chemical powder, which is discharged under pressure provided by a carbon dioxide gas cartridge. A trolley unit of 150 lb. capacity is also available, enabling the appliance to be quickly wheeled and manœuvered by one man.

On Stand C.321, G.W.B. FURNACES, LTD., attention will be directed to the Autolec range of electrode type water heaters and steam raisers, and to the Powermaster oil or gas-fired boiler. The first completely self-contained packaged boiler of its type available in Britain, the Powermaster is available in sizes ranging from 517 to 17,250 lb./hr. of steam. Supplied ready interpiped and interwired, no special foundations are required, and the boiler complies with the most stringent anti-smoke legislation.

Pneumatic dust control equipment will be shown by DALLOW LAMBERT & CO., LTD., on Stand D.427/326, together with pneumatic conveying equipment. Shown for the first time, the new Auto-Shaker will be in operation fitted to a Dustmaster unit dust collector. The filter shaker operates when the fan is switched off during, say, a mid-morning break. Other exhibits will include a range of dust collectors and scrubbers.

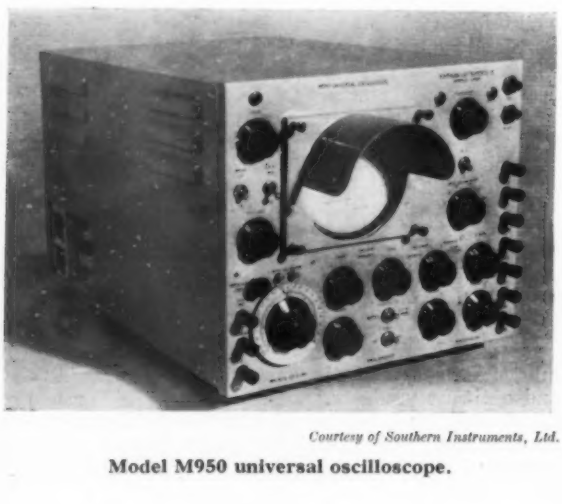
No fewer than 16 items of Tornado fan equipment will be shown by KEITH BLACKMAN, LTD. on Stand D.521/418, and the applications covered will include ventilation, dust extraction, boosting gas and air pressures, cupola, blowing, and space heating. Certain models are suitable for relatively high temperature applications.

Courtesy of Ashworth Ross & Co., Ltd.

Type 8700 cabinet dial indicator weighing machine incorporating desk.

On Stand D.626, THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LTD. will be exhibiting the main models of Ross valves for the control of air-actuated machinery. Made under licence from the Ross Operating Valve Co. of Detroit, they are of the poppet type, with oil resistant seals bonded in the seat discs. The use of corrosion resistant materials for internal fittings obviates undue maintenance. The hand and foot operated valves are designed to withstand very heavy duties, such as are encountered in foundries, steel plants, etc. Special types are available for automatic sequence control, remote control and speed control.

The latest product of ASHWORTH, Ross & Co., LTD. to be shown in the display of weighing machines on



Courtesy of Southern Instruments, Ltd.

Model M950 universal oscilloscope.

Stand D.635, is a tank-type machine incorporating a Type 7213A self-indicating platform model fitted with four levelling feet instead of wheels. It is graduated from 0 to 200 lb. in $\frac{1}{2}$ lb. divisions and is fitted with a variable cut-off switch. To show the operation of the cut-off, water will be fed from a storage tank to a tank on the platform. Other exhibits will include a Type 8700 cabinet dial indicator ; a hopper weighing machine for powdered materials ; a self-indicating bench weighing machine ; and a loose weight steelyard indicator with ticket printing attachment.

The exhibits of SOUTHERN INSTRUMENTS, LTD. on Stand C.106 will include an M950 universal oscilloscope ; an E45 Minirack four-channel oscillograph ; and a Minirack pen oscillograph. The M950 is universal in the sense that it measures not only electrical quantities, but also physical qualities by the addition of auxiliary amplifiers. Equally with the electrical or communications engineer, it is intended for the mechanical engineer who has to measure pressure, force, strain, vibration, acceleration and similar quantities.

Courtesy of Electromagnets, Ltd.

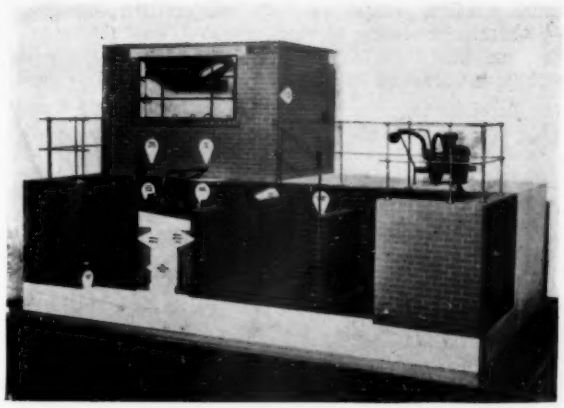
Boxmag magnetic sweeper.

A wide range of magnetic appliances will be seen on the stands of RAPID MAGNETIC MACHINES, LTD. (C.421) and ELECTROMAGNETS, LTD. (C.605). They will include separators for swarf, foundry sand, iron ore and refuse ; floor sweepers and lifting equipment.

A special feature of the stand of JOHN RIGBY & SONS, LTD. (D.607) will be a display of powder metal parts in brass, bronze, copper, nickel-silver and iron, including oil impregnated bearings.

Alongside the testing machines exhibited by SAML. DENISON & SON, LTD. on Stand D.517, there will be shown the latest design suspended weighing machines, and the Denison patented equilibrium controlled mistake-proof two-colour tape and ticket printing mechanism, as used with weighbridges, etc.

Of interest on Stand D.333/230 (MANCHESTER OIL REFINERY (SALES), LTD.) will be the petroleum-based flaw detection inks, two of which are based on the



Courtesy of Prodorite, Ltd.

Model of plant for treating effluents containing chromic acid and cyanide.

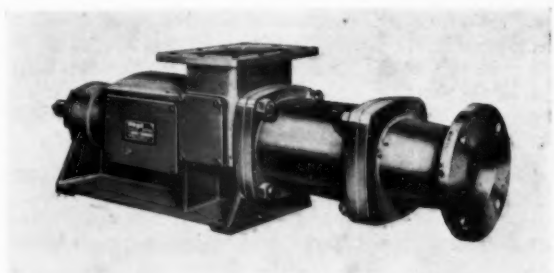
physical phenomenon of fluorescence. Visitors are invited to take along their own samples of both magnetisable and non-magnetisable materials.

A powder-type hand cleanser designed for use in industry will be demonstrated for the first time on Stand D.718 by BORAX CONSOLIDATED, LTD. It is claimed to combine the effectiveness of a heavy duty cleanser with the mildness of a baby soap. For use in cases where conditions likely to result in dermatitis have to be encountered, ROZALEX, LTD. will be showing a range of barrier creams and after-work creams (D.706).

The high-light of the GEO. SALTER exhibit on Stand A.407/306 will be a 12 ft. high spring balance designed to take weights of up to 200 tons. It is an outsize development of Salter's crane weighers, previously available for 10-cwt.–120-ton loads.

The handling of corrosive and toxic liquids and fumes is necessary in a number of processes of metallurgical interest, and on Stand D.431, PRODORITE, LTD. will be exhibiting a range of materials and constructional designs for use in combating chemical corrosion of plant and buildings. In addition to examples of acid-resisting flooring and tank constructions, the exhibits will include a number of corrosion-resisting coatings applicable to steel and concrete. On both this stand and C.404 (BAKELITE, LTD.) there will be displayed a range of P.V.C. compounds for use in piping, ducting and fans.

For pumping corrosive liquids, the display on Stand D.339 (BRITISH LABOUR PUMP CO., LTD.) will include a selection of vertical and horizontal self-priming and



Courtesy of Mono Pumps, Ltd.

The DM 12 pump for handling dry materials.

flooded suction pumps specially designed for corrosion and abrasion resisting service, whilst WYNN (VALVES), LTD., on Stand D.747 will feature straight-through diaphragm valves in ferrous and non-ferrous alloys and lined with glass, rubber, lead, nylon and polythene, for handling acids, alkalis, etc., with trouble free efficiency.

For many years the Mono pump has been used for pumping liquids, viscous fluids and moist pulps. This year, on Stand D.716, MONO PUMPS, LTD. will demonstrate their D.M. 12 pump for dry materials by pumping powder in a piped circuit within the confines of the stand.

British Patent Specifications*

698,847: A NEW STEEL MAKING PROCESS FOR THE PRODUCTION OF ALL TYPES OF AUSTENITIC, MARTENSITIC AND FERRITIC STAINLESS STEELS AND FOR CHROME-BEARING STEELS.—G. U. Noden.

THIS invention relates to a new steel-making process for the production of chromium-bearing steels, particularly stainless steel, by the method of direct ore reduction. A mixture of chrome ore, scrap metal, one or more carbonaceous agents and a slag making material, is charged directly into the furnace, and after fusing is super-heated by injection of oxygen to achieve complete reduction of the chrome ore. The completely-reduced slag is then removed and the heat proceeded with by the known oxygen injection method to remove carbon. The chromium oxide formed is subsequently reduced by the normal non-carbonaceous reducing agents, such as ferro-silicon and aluminium. The chief objects of the invention are: (*a*) to eliminate the tendency of the product to have a "gassy" nature; (*b*) to accelerate the reduction of chromium oxide associated with minimum slag volume; (*c*) to eliminate the need for using expensive ferro-chromium or any other chrome metal alloy; (*d*) to obviate the necessity for pre-heating the ore and other materials before charging into the furnace; and (*e*) in the case of stainless steel, to produce a finished steel having a low carbon content and of exceptional purity.

699,209. PRODUCING STRUCTURAL STEEL OF HIGH YIELD STRENGTH. The Vereinigte Oesterreichische Eisen-und-Stahlwerke Aktiengesellschaft, Linz a. Donau, Upper Austria.

THIS specification is concerned with a process for the production of unalloyed or low alloyed carbon steel with a high yield strength. The steel is melted in a basic open hearth furnace in the ordinary way, or in a basic open hearth furnace or basic converter by blowing with a high oxygen blast, the final slag having a ferrous oxide content greater than 20%. To the melt is added one of the following: (*a*) more than 0·5 kg. per ton of aluminium; (*b*) more than 0·2 kg. per ton of titanium; (*c*) more than 0·2 kg. per ton of magnesium; or (*d*) more than 0·2 kg. per ton of a mixture of titanium and magnesium. A feature of the process is that steels blown in the usual manner are placed after the final blow in a separate container in contact with a slag having a ferrous oxide content in excess of 20%: the additions specified are then made.

699,772. RUST INHIBITING COMPOUNDS. The Standard Oil Development Company, New Jersey.

THIS invention concerns corrosion preventing additives for mineral oils obtained by reaction between alpha pinene and a petroleum sulphonic acid. Additives can be prepared by the reaction of substantially equimolar quantities of the two substances at a temperature of 50–100° C., the reaction being normally completed in 1–3 hours. Solvents such as alcohol, alcohol-water and oil may be employed, if desired, and the sulphonic acid used can be any petroleum sulphonic acid. The additives can be used as an active rust preventing ingredient in any mineral oil solvent such as the naphthas, spindle oils and the light and heavy lubricating oil fractions. The preferred concentration is given as 1–2%.

701,541. MOULDS FOR CASTING STEEL AND IRON. The Buderu'sche Eisenwerke, Wetzlar, Germany.

ACCORDING to this invention, which relates to an improvement in a prior invention (696,301), a mould is made of a sintered mixture of industrial iron powder and substantially hydrate-free alumina powder in approximately equal proportions by weight. It is advantageous to add a gas-free fluxing agent to the powder mixture before sintering, in order to reduce the sintering temperature, for which purpose metals and metallic compounds are particularly suitable. It has also proved to be expedient to add copper in an amount up to about 10 parts by weight of the mixture. Other suitable fluxing agents suggested are mixtures or compounds containing or derived from titanic acid, for example sodium silico-titanate. In order to ensure the production of an air-tight mould, it is essential that the added agent should be free from gas, and in certain cases this must be effected by a preliminary process before adding to the mould mixture.

702,101. HEAT TREATMENT OF HARD METAL CARBIDES WITH AN AUXILIARY BINDING METAL FOR THE PRODUCTION OF A HARD METAL OF INCREASED TOUGHNESS. Gebr. Böhler & Co. Aktiengesellschaft, Vienna, Austria.

THIS specification concerns a process for the heat treatment of hard metal carbides with an auxiliary binding metal for the production of sintered hard metals having increased toughness. The binding medium may be one or more metals of the iron group, and a feature of the process is a heat treatment following a normal sintering operation, which is intended to precipitate the hard components dissolved in the binder. The heat treatment consists of annealing at temperatures between 600 and 1,000° C. (preferably 800–900° C.) for 2–10 hours. Increased toughness is achieved in a normal way by suitable grading of the grain size of the hard component. The application of the process to hard metals comprises a fine portion of hard component having a grain size of 0·5–2μ, and a coarse portion of a grain size of 2–5μ, the respective amounts of these two grain sizes being selected within the ratios of 1 : 3 and 3 : 1.

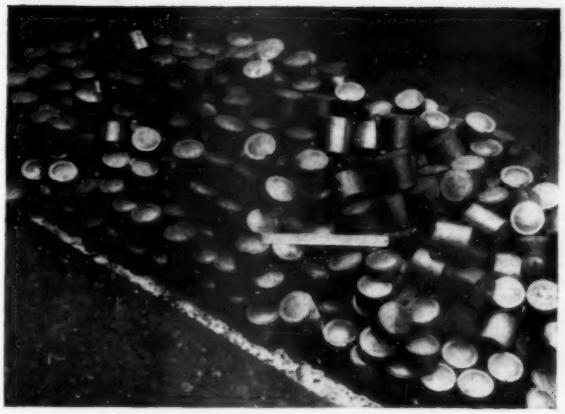
* Abstracted from British Patent Specifications and Abridgements by permission of the Controller of H.M. Stationery Office. Copies of the Specifications can be obtained from the Patent Office (Sale Branch), 25, Southampton Buildings, Chancery Lane, London, W.C.2. Price 2s. 8d. per copy (including postage).

Briquetting Press for Metal Swarf

Cast Iron Prepared for Cupola Remelting

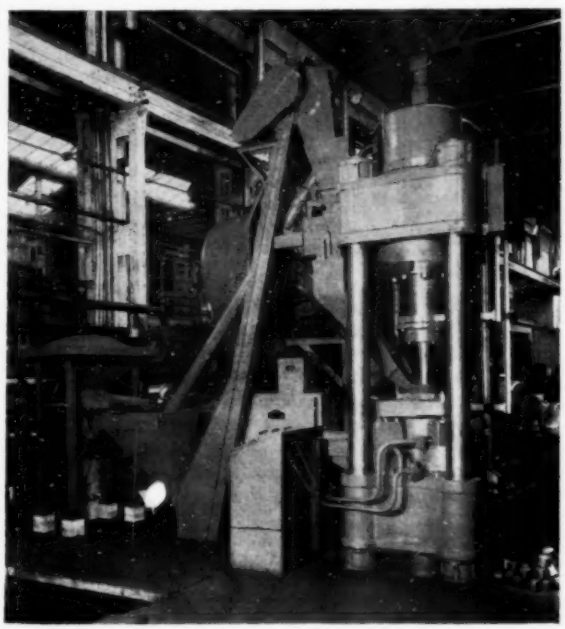
CAST iron borings or swarf represent a valuable source of good quality scrap, but their recovery on an economic basis is not without difficulty. Including them as part of the charge to the cupola results in a considerable loss of material, due to the fine borings being burnt and carried away in the flue gases before they can descend to the melting zone. This difficulty can be overcome in one of two ways : by using a different type of melting furnace ; or by introducing the swarf into the cupola in such a way that it is not blown out.

A recent contribution to the solution of this problem is a 400-ton hydraulic briquetting press, of revolutionary design, which has been developed by Fielding & Platt, Ltd., as a result of a realisation, arising from their experience with scrap metal baling presses, of a latent demand for equipment designed to assist in the conservation of ferrous and non-ferrous materials of a type not readily possessed by conventional baling equipment. The new machine is fully automatic in operation, and is capable of converting small cast iron borings into high density briquettes at a constant and rapid production rate. There is no bonding or sintering, and the briquettes when made can be conveniently handled and conveyed direct from the press to the cupola or furnace for re-melting.



A pile of cast iron briquettes.

The melting in the cupola of cast iron borings which have been briquetted by hydraulic pressure is a practical proposition, and it appears that briquettes having a density of approximately 85% can form a direct substitute for pig iron, with only small losses due to melting.



The Fielding & Platt 400-ton briquetting press and ancillary equipment.

The Press

The press, which is of the vertical four-column type, has fabricated tables with a mould assembly mounted on the bottom table, and is self-contained and complete with its own hydraulic pumping unit using oil as the pressure medium. It has been designed for the production of high density briquettes, in suitable sizes and forms, from cast iron swarf, in order that the briquettes so made can be conveniently handled and conveyed to the furnace and re-melted. With certain modifications, this machine can be adapted for producing briquettes from swarf of certain non-ferrous metals, such as brass and aluminium.

The press conforms to the following principal characteristics :—

Power of Main Ram	400 tons
Stroke of Main Ram	15 in.
Specific Pressure on Material	48 tons/sq. in.
Total Time Cycle of Press	11·5 sec. (approx.)
Weight of Briquette	4 to 6 lb.
Average Density	85% (approx.)
Output of Briquettes	300–340/hr., or 0·7–0·9 tons/hr.

The control of the press is by electrical push-buttons through D.C. solenoid operated valves, which are of the balanced type for operating with oil, the complete control equipment being arranged for automatic operation. The pressure medium used is oil, which is supplied from two high-speed radial pumps driven by one 80 and one 50 h.p. motor.

Mode of Operation

Swarf is loaded into the bunker, which has a capacity of approximately 1 ton ; based on the production of briquettes weighing 4 to 6 lb. each, this represents storage capacity for about an hour's working. From the bunker, swarf pours on to a vibrating screen which

rejects large pieces of metal or other unsuitable materials, which are then carried away down the small reject chute fitted at right angles to the direction of flow.

The screened material then passes into the reservoir at the foot of the elevator, from which it is carried to the small hopper at the top of the machine by flights on the elevator chain. A vibrator attached to this hopper ensures a continuous supply of swarf into the dispenser. This is a device for measuring by weight the correct amount of swarf required to make one briquette. After filling, it is tipped by air cylinders in order to discharge its load down the chute and into the mould ready for briquetting. As soon as the swarf is discharged, the dispenser is immediately returned to its original position. The action of the dispenser is fully automatic and interlocked with the pressing cycle of the machine. Should the elevator supply swarf faster than the machine can deal with it, an overflow pipe is fitted above the dispenser to return the surplus to the lower reservoir.

The main ram mandrel now enters the mould or container and presses a briquette. Pressure is then locked in the main cylinder while the mould is lifted by four small lifting rams and the briquette is stripped from the mould. The main ram is then returned to the up or filling position, thus releasing completely the briquette, which is then ejected from the press by the plunger of a horizontal air cylinder.

The finished briquette is then pushed down a small chute where a suitable receptacle or conveyor is placed to receive it. The mould is now returned to the filling position when the dispenser re-charges it with swarf and the complete operation is repeated.

New and Revised British Standards

RAILWAY ROLLING STOCK MATERIAL—COPPER (B.S.24. Part 5 : 1954) Price 4s.

THIS revised edition specifies requirements for copper in the following forms :—

Specification No. 11 : 'Copper Plate for Locomotive Fireboxes.'

Specification No. 12 : 'Copper Rod for Locomotive Stay Bolts, Rivets, etc.

Specification No. 13 : 'Copper Tubes for Locomotives.'

The requirements previously covered separately by Specifications Nos. 12 and 12a, for rolled and extruded rod respectively are incorporated in the one specification, No. 12, and those for copper tubes and pipes for locomotive boilers previously covered by Specifications Nos. 13 and 15, respectively, have been incorporated in Specification No. 13 under the title 'Copper Tubes for Locomotives.' Specification No. 14, 'Brass Tubes for Locomotive Boilers,' which was included in the earlier edition of the standard has been omitted, as the small demand for brass tubes for locomotive boilers is met by the existing B.S.885, 'Brass Tubes for General Purposes.'

Details of chemical composition have not been included but reference has been made to B.S.1173, 'Tough Pitch Arsenical Copper' and B.S.1174, 'Phosphorus-deoxidized Arsenical Copper' where appropriate, and copper complying with the latter standard has been permitted as an alternative to the former for rod material. In some cases tolerances and mechanical properties have been modified and a gassing or hydrogen embrittlement test has been added for deoxidised material in the form of plate and rod. Wherever possible, the individual specifications have been modelled on the corresponding general purpose standards, but the main requirements are substantially unaltered from the earlier edition.

SIZE ANALYSIS OF COKE (B.S.2074 : 1954). Price 6s.

THIS standard is applicable to all types of coke, including blast furnace coke, foundry coke and graded gas and oven coke for domestic and industrial purposes. It describes the size of sample to be taken, the method of collecting the sample, and the method of analysing the sample. An important feature of the specification is the introduction of a method of checking the accuracy of sampling, based on sub-division of the sample and the separate analysis of the sub-samples so obtained. The weight of sample to be taken in subsequent similar consignments can then be adjusted to be the minimum necessary to give the required accuracy. The procedure varies according to whether single isolated consignments or regular similar consignments are being sampled.

DIMENSIONS OF 3-PHASE ELECTRIC MOTORS (B.S.2083 : 1954) Price 2s. 6d.

THIS British Standard deals with the dimensions of 3-phase electric motors, and establishes nine frame sizes for squirrel-cage, totally enclosed fan-cooled foot-mounted motors intended for industrial purposes and having a maximum continuous rating. It is applicable to 50-cycle motors at voltages not greater than 650 volts, and covers motors of 1–20 horse-power at 1,500 r.p.m. (synchronous speed). With the exception of the 1 h.p. 4-pole motor, the dimensions specified are similar to those given in the American NEMA Standard MG 1–1949, but for a given frame size the horse-power outputs have been increased to fall into line with practice in this country, and shaft dimensions have been enlarged accordingly. It is recognized that there will be a considerable transition period before all motors can be supplied exactly in accordance with this Standard, and mutual agreement between contracting parties as to the extent of its application may initially be necessary.

METHODS FOR THE DETERMINATION OF MAGNETIC PERMABILITY OF IRON AND STEEL BARS, FORGINGS AND CASTINGS (B.S.2454 : 1954) Price 2s. 6d.

THIS new British Standard deals with the determination of the normal magnetization curve connecting flux density and magnetizing field of iron and steel (other than permanent magnet materials) in the form of bars, forgings and castings. The preparation of this British Standard was prompted by the issue of B.S.1617 'Mild Steel Castings of High Magnetic Permeability.' It is not, however, restricted to castings as the methods can be applied to iron and steel in any form, provided the demensions are such that the necessary test pieces can be obtained. Parts 1 to 4 give the basic requirements of the methods, and an appendix gives full details of the recommended procedure for testing ring and bar specimens.

Copies of these standards may be had from the Sales Branch, British Standards Institution, 2, Park Street, London, W.1.

Molybdenum-Wound Electric Furnaces

Calculation of Winding Dimensions

By A. B. Ashton, M.Sc., F.I.M.

Research Manager, Vactite Wire Co., Ltd.

The unusual electrical characteristics of molybdenum call for features in design which are peculiar to molybdenum-wound furnaces. In this article, the author discusses the factors involved and details the method of calculating winding dimensions using both wire and tape.

ELECTRIC resistance furnaces wound with molybdenum heating elements are finding increasing application in modern furnace technology. In many ways the basic principles of their construction are similar to those for furnaces wound with other metallic resistors. There are, however, two characteristics peculiar to molybdenum windings which call for unusual features in the furnace design. One is the fact that molybdenum does not form a protective oxide coating, but is rapidly converted into the volatile trioxide at temperatures exceeding about 500° C. To prevent this it is necessary to operate furnace windings in a non-oxidising atmosphere and the furnace must be designed accordingly. The second concerns the unusual electrical characteristics of molybdenum: at atmospheric temperatures the resistivity is unusually low, but a high temperature coefficient results in a resistivity more comparable with those of other resistance materials at operating temperatures. These electrical characteristics call for features in design which are peculiar to molybdenum-wound furnaces.

At atmospheric temperatures, molybdenum is hardly a "resistance" material at all, as it shows a specific resistivity of the order of 5 microhm cm., whereas the values associated with other resistance alloys are generally upwards of 100 microhm cm. At temperatures of 1,400° C. and upwards, however, this figure increases eight to ten-fold. At these temperatures, therefore, it becomes possible to design molybdenum heating elements which will dissipate the necessary power at voltages which are conveniently high and currents which are conveniently low, without reducing the cross-section of the winding to impracticably small dimensions.

The dimensions, in cross section and in length, of the winding of any required furnace can be calculated when five basic factors have been decided. They are power input, operating temperature; working voltage, shape of resistor (circular or rectangular), and superficial watts density on the winding.

Basic Design Factors

Power Input.

The power input required is a function of a large number of factors. It is not within the scope of this paper to discuss them in detail, but it is relevant to point out that, for any given temperature and rate of charge throughput, the power required is governed very considerably by the efficiency of the thermal insulation. In designing molybdenum furnaces it is wise to pay more attention than usual to thermal insulation, in order that the power input may be kept as low as possible. In this way the mass of molybdenum required to dissipate the power is also kept as low as possible. This is of more importance in larger furnaces with high power inputs; it has to be remembered that molybdenum is made by a powder metallurgy process which limits the largest piece which can be made, and excessive requirements in the way of power dissipation may call for a larger mass of molybdenum than is available.

It is necessary to decide the required power input from the usual considerations which govern electric resistance furnaces.

Operating Temperature.

The operating temperature will, of course, depend on the purpose for which the furnace is intended. It may range from 1,200°C. to about 1,700°C. or more, and its significance from the viewpoint of calculating the winding dimensions lies in its effect on specific resistivity.

Fig. 1 shows graphically the results of Worthing's measurements[1] of the specific resistivity of molybdenum at temperatures between 0° and 1,927°C. Specific resistivity is, of course, a

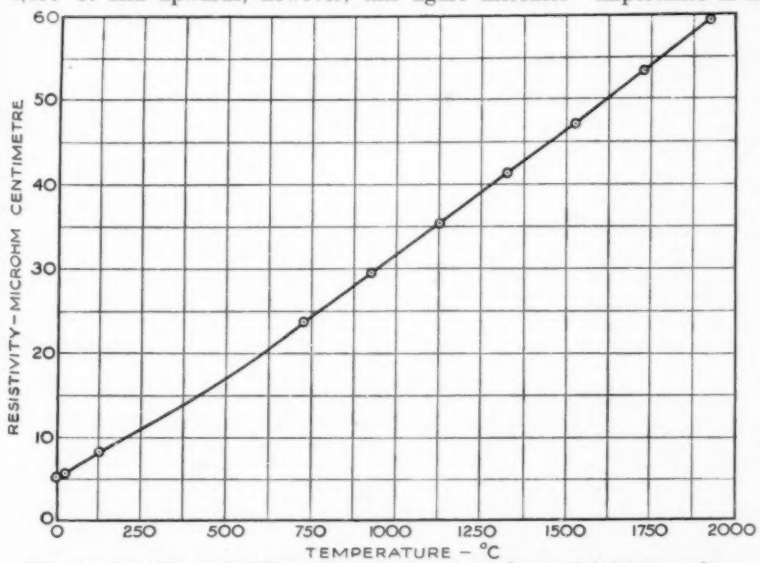


Fig. 1.—Specific resistivity—temperature curve for molybdenum (after Worthing).

fundamental quantity in the winding calculations, and the curve shows how very considerably it changes with temperature.

In practice, it is wise to estimate on the high side when deciding the maximum temperature for which to design. Having decided this temperature the appropriate specific resistivity can be taken from Fig. 1 and used in the formulae given below.

Working Voltage.

The working voltage also must be considered under the conditions which will obtain at the working temperature, when the voltage across the winding will be at its maximum. There is some measure of latitude, although it should not be too high, for voltages between adjacent turns may then be unpleasantly large. Some of the refractories used for tubes and supports become appreciably conductive at high temperatures, and if the inter-turn voltage is high hot spots may develop. On the other hand, it should not be too low, for then the current demands (to yield the necessary power) become high, and the voltage regulating gear becomes awkward to design. Voltages of the order of 50 to 150, depending somewhat on the size of the furnace, are generally convenient to adopt.

Shape of Resistor Section.

The winding may be made with round wire or rectangular section strip (or tape). Each has its own advantages. Round wire is easier to wind, more easily permits terminal connections to be made, and at any given pitch of winding it has a greater distance between turns. It also has a greater immunity from failure at hot spots arising from volatilisation of the molybdenum. Strip, on the other hand, makes a more compact winding and for any given cross sectional area (and hence resistance per foot run) it has a greater surface area and allows a greater power dissipation at any particular superficial watts density.

Whilst wire has only one measurement in its cross-section, strip has two, and the winding calculation must determine both. A preliminary decision must be made as to the width/thickness ratio before the calculation can be carried out. In theory, this ratio can vary, but it is best kept within fairly narrow limits in order to help the molybdenum manufacturer, for molybdenum strip is not easy to produce in long lengths with a high width/thickness ratio. A convenient ratio to adopt is 5/1.

A proviso to this recommendation is called for in connection with the smaller strip sections. The thickness of the strip should not fall below about 0·020 in., for if it does small irregularities in section (due to damage in handling or to the inevitable, though small, manufacturing variations) become appreciable in relation to the thickness, and cause a tendency towards local hot spots. If an assumed width/thickness ratio of 5/1 leads to a calculated thickness of less than 0·020 in., then a smaller ratio than 5/1 should be adopted.

Watts Density.

Watts density is the power dissipated in watts/sq. in. of resistor surface at the maximum operating temperature, and is a measure of the intensity of loading of the resistor. To a large extent, watts density is decided according to the relative importances of (*a*) first cost of the winding, and (*b*) length of life. A low watts density calls for a larger winding, and hence for a higher first cost, but it increases the probability of a longer winding life. A high watts density tends to reverse all three consequences.

Low watts densities are more likely to be economically justifiable under the following conditions :

(1) Where continuity of operation is important and a shut-down for re-winding is a serious matter.

(2) Where the furnace is subjected to careful treatment and is not likely to fail as a result of accidents, such as gas supply failure, contamination with fusible oxides, mechanical penetration of the tube, etc. Some workshop furnaces are subject to rather pronounced hazards in these respects, and are inevitably likely to fail from such causes. Under such conditions it is obviously unjustifiable to use an expensive winding for winding burn-out is not likely to be the governing factor in determining winding life.

Furnaces with which the writer has been associated have operated at densities between 10 and 20 watts/sq. in. and have given very satisfactory lives at temperatures of 1,450–1,500° C. References have been seen to densities of 40 and even higher. Such values are regarded as high, 10 to 20 being regarded as low.

Calculation of Winding Dimensions

With the above five factors decided, the calculations for the winding can proceed. Basically, they are the same for both wire and strip, but there are slight differences and each is treated separately below.

Method of Calculation

Wire.

At the maximum operating temperature, let

Power Input	$= W$ watts
Watts Density	$= K$ watts/sq. inch.
Voltage	$= V$ volts
Current	$= C$ amps
Resistance	$= R$ ohms
Specific Resistivity	$= \rho$ microhm centimetres
Wire Diameter	$= d$ inches
Wire Length	$= l$ feet

Then

$$K = \frac{W}{12l\pi d}$$

$$\therefore \quad l = \frac{W}{12K\pi d} \qquad (1)$$

also

$$R = \frac{12l\rho}{2{\cdot}54 \times (\pi d^2/4) \times 10^6}$$

$$= \frac{48l\rho}{2{\cdot}54 \times \pi d^2 \times 10^6} \qquad (2)$$

$$C = \frac{V}{R} = \frac{V \times 2{\cdot}54 \times \pi d^2 \times 10^6}{48l\rho}$$

$$\text{and} \quad W = \frac{V^2}{R} = \frac{V^2 \times 2{\cdot}54 \times \pi d^2 \times 10^6}{48l\rho} \qquad (3)$$

Then, from (1) and (3), substituting for l in (3),

$$W = \frac{V^2 \times 2{\cdot}54 \times \pi d^2 \times 10^6 \times 12\,K\pi d}{48\rho W}$$

$$\therefore \quad d^3 = \frac{48\rho W^2}{2{\cdot}54 \times 12 \times 10^6 \times \pi^2 \times V^2 K}$$

$$\therefore \quad d = 0{\cdot}005424 \sqrt[3]{\frac{\rho W^2}{V^2 K}} \qquad (4)$$

This formula gives the required wire diameter in inches. The value obtained is then substituted for d in equation (1), which then yields the value of l in feet. The winding is then fully determined.

In purchasing wire for the winding, allowance must be made for connections between the ends of the tube winding and the feed terminals. These are best made with three wires of the same diameter as the hot winding in order to minimise heat generation near the terminals. The length of wire used should, therefore, comprise the length as calculated plus three times the distance between winding ends and terminals, making allowance for both ends, of course.

Strip.

Using the same notation as for wire, but with the addition of w and t for the width and thickness (both in inches) respectively, of the strip,

Then

$$K = \frac{W}{12l \times 2(w+t)}$$

$$= \frac{W}{24l\,(w+t)}$$

$$\therefore \quad l = \frac{W}{24K(w+t)} \tag{5}$$

also

$$R = \frac{12l\rho}{2{\cdot}54 \times wt \times 10^6} \tag{6}$$

$$C = \frac{V}{R} = \frac{V \times 2{\cdot}54 \times wt \times 10^6}{12l\rho}$$

and $$W = \frac{V^2}{R} = \frac{V^2 \times 2{\cdot}54 \times wt \times 10^6}{12l\rho} \tag{7}$$

Then, from (5) and (7), substituting for l in (7),

$$W = \frac{V^2 \times 2{\cdot}54 \times wt \times 10^6 \times 24K(w+t)}{12\rho W}$$

$$\therefore\ wt\,(w+t) = \frac{12\rho W^2}{2{\cdot}54 \times 24 \times 10^6 \times V^2K}$$

$$= 0{\cdot}1968 \times 10^{-6} \times \frac{\rho W^2}{V^2K} \tag{8}$$

Equation (8) relates the decided factors with a function of w and t. To calculate the latter separately, it is necessary to introduce the width/thickness ratio. Let this be x, so that :

$$x = \frac{w}{t}$$

Then $$w = xt \tag{9}$$

and $$wt(w+t) = xt^2(xt+t)$$

$$= xt^3(x+1)$$

Substituting for $wt(w+t)$ in (8),

$$xt^3(x+1) = 0{\cdot}1968 \times 10^{-6} \times \frac{\rho W^2}{V^2K}$$

$$\therefore \quad t^3 = \frac{0{\cdot}1968 \times 10^{-6} \times \rho W^2}{V^2Kx(x+1)}$$

$$\text{and } t = 0{\cdot}005817 \sqrt[3]{\frac{\rho W^2}{V^2Kx(x+1)}} \tag{10}$$

w can then be obtained from equation (9) and l from equation (5), end allowance being made as in the case of wire windings.

Examples

Wire.

For

Power Input	$= W = 5{,}000$ watts
Watts Density	$= K = 20$ watts/sq. in.
Voltage	$= V = 100$ volts
Current	$= C$ amps.
Resistance	$= R$ ohms.
Specific Resistance	$= \rho = 45{\cdot}6$ microhm centimetres at the operating temperature (1,500° C.)
Wire Diameter	$= d$ inches
Wire Length	$= l$ feet

Then from equation (4)

$$d = 0{\cdot}005424 \times \sqrt[3]{\frac{\rho W^2}{V^2K}} \text{ inch}$$

$$= 0{\cdot}005424 \times \sqrt[3]{\frac{45{\cdot}6 \times 5{,}000^2}{100^2 \times 20}} \text{ inch}$$

$$= 0{\cdot}09686 \text{ inch}$$

And

$$l = \frac{W}{12K\pi d} \text{ feet}$$

$$= \frac{5{,}000}{12 \times 20 \times 3{\cdot}142 \times 0{\cdot}09686} \text{ feet}$$

$$= 68{\cdot}46 \text{ feet}$$

These calculated measurements would be rounded off to 0·097 inch and 68 feet.

Strip.

Using the same details as for the wire example worked out above, with the addition of w and t as the width and thickness (both in inches) respectively, of the strip, and of 5 for the width/thickness ratio x, then, from equation (10)

$$t = 0{\cdot}005817 \times \sqrt[3]{\frac{\rho W^2}{V^2Kx(x+1)}}$$

$$t = 0{\cdot}005817 \times \sqrt[3]{\frac{45{\cdot}6 \times 5{,}000^2}{100^2 \times 20 \times 30}} \text{ inch}$$

$$= 0{\cdot}005817 \times 5{\cdot}75 \text{ inch}$$

$$= 0{\cdot}03345 \text{ inch}$$

and $w = 0{\cdot}16725$ inch

These calculated measurements would be rounded off to 0·033 inch and 0·167 inch.

In either of these examples, the resistance in ohms of the winding at the operating temperature can be calculated from the appropriate equation, namely, (2) for the wire and (5) for the strip. Furthermore, by substituting the room temperature value of ρ in these two equations (after calculating d or w and t for the high temperature conditions) the resistance of the winding at room temperatures can be calculated.

Power Regulation

The marked change of resistance with temperature shown by molybdenum has consequences which govern the design of the power regulation gear by which molybdenum-wound furnaces are controlled. The cold resistance of such a furnace may be as little as one tenth of its resistance at the operating temperature, and if it were connected when cold to the full operating voltage, then ten times the operating current would pass. This means that whatever kind of power control is used it must be capable of a wide degree of voltage regulation.

Otherwise, there will certainly be very heavy current surges when switching on, and possibly damage to the furnace as a result of too rapid a heating rate.

Series rheostats are losing favour on account of their power wastage, but they may still be convenient for relatively small furnaces in laboratories and workshops. They should have a resistance at least equal to the resistance of the winding at the operating temperature, and preferably 5 to 10% more so as to allow accurate regulation of temperature when operating. Power efficiency at operating temperature requires the rheostat to be cut out almost completely. Since rheostat-controlled furnaces are generally fed directly from the mains (without interposition of a transformer) this means that very nearly the full mains voltage is applied across the winding at the operating temperature. Furthermore the winding has a high potential to earth.

The most efficient way of regulating power is by a variable transformer of some kind, either of the auto-type or one with infinitely variable coupling. Both give satisfactory regulation, but the former has the drawback of a high earth potential on the winding, which can result in shocks to operators when manipulating charges with metal push rods ; it is not necessary to touch the windings to cause this phenomenon, as most of the refractories used become appreciably conductive at high temperatures.

Energy regulators of the cycling on-off type obviously cannot be used alone. They may, however, be compounded with coarsely tapped rheostats or transformers, the tappings being used to regulate the current flow when the furnace is cold, and the energy regulator to regulate the power input for exact temperature control when the furnace has reached its operating temperature.

REFERENCE
1. A. G. Worthing, *Physical Review*, 1926, **28**, 174-201.

Argonarc Welding Exhibition in Scotland

AN exhibition of first importance to shipbuilders and the whole of the metalworking industry in Scotland was held during the week 8th to 12th March. This exhibition, arranged by the British Oxygen Company, of Polmadie, was designed to show the impact of the argon welding processes on the fabrication of aluminium, stainless steels and copper-base alloys. The term Argon processes covers all of the inert gas shielded electric arc processes sponsored by The British Oxygen Company. These include the ordinary manual Argonarc process, using a non-consumable electrode and separate filler rod, the Argonarc spot welding process, which also employs a non-consumable electrode and is used for making spot welds where there is access to one side of the joint only, and the Argonaut process, which has a consumable electrode formed by the filler rod or wire.

Briefly, the ordinary Argonarc process is employed for downhand welding on material up to the following thicknesses : aluminium $\frac{3}{8}$ in., magnesium $\frac{3}{5}$ in., stainless steel $\frac{5}{16}$ in., nickel, lead and brass $\frac{1}{4}$ in., copper, silver and Everdur $\frac{1}{4}$ in. The spot welder is principally for use on stainless steel and bright mild steel. It may be operated in any position and, provided the top sheet is not more than $\frac{1}{16}$ in. thick, it will make welds to any thickness of lower sheet or section with access to the top only. Argonaut is also a manual process, but as its name implies, the filler wire is fed automatically and the arc is self-regulating. The advantages of the Argonaut process are that it may be employed in any position, it will weld much heavier material—there is no practical thickness limit with multi-pass techniques—and it is much faster than any other means of welding on aluminium, stainless steel and copper base alloys. All the Argonarc processes have, of course, the major advantage of being employed without the use of flux, and hence there are no post-weld cleaning and corrosion problems.

The demonstrations which accompanied the exhibition were arranged to show the possibilities of each of the processes within its own sphere of application, the range of materials and material thicknesses covered being such as to provide a practical indication of the manner in which each process could be applied to current fabrication problems in the different industries.

A demonstration of the Argonarc spot welding process.

The static exhibition included a display of photographs provided by the British Aluminium Co., Ltd., covering the construction of the yacht *Morag Mhor*—the first vessel to be built entirely of aluminium and Argonaut welded throughout. Practical proof of the advantages of the Argon processes was given by the many examples of work lent by customers in the area. These included pressure vessels, tanks, light and heavy pipework, sternframes, filters and a variety of other industrial and domestic applications in all the metals to which the processes are suited. Many well-known Scottish manufacturers co-operated in this so as to give a most comprehensive and informative exhibit.

A twice daily showing of The British Oxygen Company's Argonarc film completed the survey of what these "up to the minute" processes provide in the continual search for higher industrial efficiency. In addition to the services of B.O.C. technicians who were on hand throughout to answer technical queries, a complete range of literature was provided for every interested visitor.

NEWS AND ANNOUNCEMENTS

Symposium on Powder Metallurgy, 1954

THE Iron and Steel Institute, in association with The Institute of Metals, is organising a Symposium on Powder Metallurgy, to be held on Wednesday and Thursday, 1st and 2nd December, 1954, in Church House, Westminster, London, S.W.1. On both days there will be morning and afternoon sessions for the discussion of the papers, which will cover both ferrous and non-ferrous aspects of powder metallurgy, and a small exhibition of powder metallurgy components is being prepared.

The arrangements have been entrusted to the following organising committee: DR. IVOR JENKINS (General Electric Co., Ltd.), (Chairman); MR. L. J. BRICE (Ministry of Supply); DR. W. D. JONES (Consultant); MR. D. A. OLIVER, C.B.E. (B.S.A. Group Research Centre); DR. L. B. PFEIL, O.B.E., F.R.S. (Mond Nickel Co., Ltd.); DR. T. RAINE (Metropolitan-Vickers Electrical Co., Ltd.); MR. E. ROBSON (Manganese Bronze and Brass Co., Ltd.); and MR. K. HEADLAM-MORLEY (Iron and Steel Institute) (*Secretary*).

A large number of papers is being specially written for the Symposium, and will be presented and discussed in the following three main groups: I.—Metal Powders and their Assessment; II.—Research and Production Practice; and III.—Production and Properties of Engineering Materials. The papers, together with the proceedings and discussion, will subsequently be published in a bound volume.

The Symposium will be open to all interested in powder metallurgy, whether members of The Iron and Steel Institute and Institute of Metals or not, and a cordial invitation to take part in the proceedings is extended to all members of The Faraday Society, The Institute of Physics, The Institution of Electrical Engineers, The Institution of Mechanical Engineers, The Institution of Metallurgists, The Institution of Mining and Metallurgy, The Institution of Production Engineers, The Physical Society and The Society of Chemical Industry. Anyone wishing to receive further particulars, the programme of the Meeting, and a form of application when available, should write to the Secretary, The Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, asking to be placed on the mailing list for this purpose.

Spring Welding Meeting

THE Spring Meeting of the Institute of Welding is being held this year from April 28th to May 1st in South Wales and Bristol. It will open with an informal gathering and Technical Film Show at Porthcawl, Glamorganshire, on the evening of Wednesday, April 28th. The morning of April 29th will be devoted to the presentation and discussion of papers on "Steelmaking and Welding" (Dr. L. Reeve) and "Hydrogen—Barrier to Welding Progress" (Dr. C. L. M. Cottrell). Following an afternoon visit to the Abbey Works of the Steel Company of Wales at Port Talbot, Members will travel to Bristol, where two papers on "Nitrogen-Arc Welding of Copper" will be presented by Dr. K. Winterton and Messrs. E. Davis and C. A. Terry on the Friday morning. Friday afternoon will be taken up by visits to a number of works in the Bristol area, and in the evening there will be a dinner at the Grand Hotel. The Meeting will conclude with a technical session on Saturday morning at which papers on "Welding in the Aero Engine Industry—Reflections on Organisation by a Production Engineer," and "Welding as a Career," will be presented by Mr. F. G. C. Sandiford and Mr. F. Koenigsberger, respectively.

Institute of Metals Spring Meeting

As has already been announced, a Joint Meeting of the Institute of Metals and the Société Française de Métallurgie will be held from April 26th to May 1st, in London. At the request of the French society, an additional technical session will be held on the afternoon of Wednesday, April 28th, when three papers from France will be presented in French and discussed in French and English.

Summer School in Mineral Dressing

A SUMMER School in Mineral Dressing will be held in the Bessemer Laboratory, Royal School of Mines, Prince Consort Road, London, S.W.7, from Tuesday, September 14th to Friday, September 17th, 1954. The course includes lectures covering comminution, classification, grinding control, gravity separation, flotation and ancilliary processes, and is illustrated by films, demonstrations and classwork. The sessions cover the period from 10 a.m. to 5 p.m. each day. Application forms may be obtained from the Registrar at Imperial College, Prince Consort Road, London, S.W.7. The fee for the course is £10 10s. It is possible that arrangements can be made for accommodation of those attending if notice is given in time.

I.B.F. Jubilee Paper Competition

IN connection with the fiftieth anniversary celebrations of the establishment of the Institute of British Foundrymen, the Institute organised a Jubilee competition open to all the younger members of the Institute. A separate competition was held for each of the Institute's branches submitting a minimum number of entries, and the winners, together with competitors in other branches, were considered for the National Award. The Adjudicators have now announced the results, which are as follows:—

National Award

DENNIS FREDERICK BAILEY of Coventry for his paper "Some Aspects of Shell Moulding Technique."

Branch Prizes

Birmingham Branch—DENNIS FREDERICK BAILEY, for his paper: "Some Aspects of Shell Moulding Technique."

Lancashire Branch—ROBERT KIRKHAM JACKSON, for his paper: "Shell Moulding and the Economic Use of Shell Moulding Material."

London Branch—NEVILLE YOXALL NEWTON, for his paper: "Some Aspects of Metallurgical Control in the Modern Steel Foundry."

Newcastle Branch—WILLIAM BURN HENDRY, for his paper: "Some Influences of Cupola Charge Composition upon the Properties of Grey Cast Iron."

Tees-side Branch — ALAN DALE, for his paper: "Microscopy in the Iron Foundry."

The National Award was presented at the Institute's Jubilee Lecture held at the Café Royal, Regent Street, London, on Friday, April 9th and the branch prizes will be presented at meetings of the respective branches.

Personal News

HENRY WIGGIN & CO., LTD., announce a number of new appointments to take effect on May 1st. MR. J. O. HITCHCOCK will relinquish his position as Assistant Managing Director of Henry Wiggin & Co., Ltd., to assume the position of Assistant to the Chairman of the Mond Nickel Co., Ltd. He will remain a member of the Wiggin Board. MR. H. W. G. HIGNETT, Superintendent of the Mond Nickel Company's Development and Research Laboratory, has been appointed to the Wiggin Board and will take charge of technical (metallurgical) control and development in all the Wiggin plants. He is succeeded as Superintendent of the Laboratory by MR. H. EVANS. MR. R. E. ANSELL, Manager of the Sales Department, becomes a member of the Wiggin Board. MR. O. LEWIS JONES will be General Production Manager, responsible for production in all the Wiggin plants. He is succeeded as Works Manager at Birmingham by MR. C. E. WINFIELD. At the Zenith Works, Glasgow, the General Manager, MR. A. B. GRAHAM, will relinquish this position on July 1st, but will continue with the organisation to undertake special duties in connection with production. He will be succeeded as Works Manager at Zenith by MR. R. J. P. MACDONALD.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., announces that DR. C. DANNATT, O.B.E., M.C., has been appointed Deputy Managing Director. MR. A. C. MAIN, Director and Works Manager, Trafford Park Works, has been appointed Director of Manufacture, and MR. E. W. STEELE, formerly Director and General Manager of Works, has retired from executive duties but remains a Director of the Company. MR. J. F. PERRY, Managing Director of Metropolitan-Vickers Electrical Export Co., Ltd., has been appointed a Director of the parent company.

MR. J. C. HOWARD, a Director of Electric Furnace Co., Ltd., has been made a Director of EFCO Engineering Co., Ltd.

GEO. SALTER & CO., LTD., of West Bromwich, announce that MR. G. RUSHTON, Sales Manager of the company's Roller Bearing Division, has been appointed, additionally, Sales Manager of the Retaining Ring Division.

MR. H. P. WHITE has recently been appointed Head of the Data and Publications Section of the Mullard Technical Service Department. One of Mr. White's principal responsibilities will be compiling and publishing technical data and information on the applications of Mullard valves and tubes.

MR. H. C. WESSON has been appointed to the staff of the Lead Development Association.

CONSEQUENT on the death of SIR PAUL GUETERBOCK who had been Managing Director of Capper Pass & Son, Ltd., since 1937, the HON. J. F. A. ROCHE and MR. E. H. JONES have been appointed Joint Managing Directors to succeed him. LT. COL. S. G. C. MACWATTERS has been appointed to the vacant seat on the Board.

MR. W. PATON, formerly Senior Metallurgist with Federated Foundries, Ltd., Glasgow, has now joined the technical staff of British Electro Metallurgical Company, A Division of Union Carbide, Ltd. He will be located at the Glasgow Office, 44, York Street.

MR. C. P. BIRKIN has been appointed to succeed the late MR. W. E. BENBOW as Editor of "Iron and Steel."

THE REGENT OIL CO., LTD., announces the appointment of MR. J. D. GARST as its Operations Director. He will be responsible for the operation of the Bulk Storage and Transport Divisions of the company. MR. O. H. FISH has been appointed Assistant General Sales Manager.

DR. H. L. SAUNDERS, who has been Head of the Iron-making Division of The British Iron and Steel Research Association since its establishment in 1945, is to retire at the end of April because of ill health. Dr. Saunders is one of B.I.S.R.A.'s earliest links with the steel industry's organisations for co-operative research which preceded the foundation of the Association itself, as he took up work on the mechanism of blast furnace reactions at Imperial College in 1925, this work being financed by the National Federation of Iron and Steel Manufacturers (later the Iron and Steel Industrial Research Council).

WELLWORTHY, LTD., of Lymington, Hants., announce that MR. H. DUNN has been appointed Sales Manager, Scottish Area. His office address remains unchanged at 50, Wellington Street, Glasgow, C.2.

MR. P. M. HOLLINGSWORTH has recently been appointed Chief Engineer of the Power Cables Division of British Insulated Callender's Cables, Ltd., to succeed MR. W. P. FULLER on his eventual retirement.

MR. R. A. STAUFFER and MR. K. G. DONALD have been elected to the Board of Directors of National Research Corporation, Cambridge, Massachusetts.

DR. G. P. CONTRACTOR, formerly Assistant Director of the National Metallurgical Laboratory of India, whose first assignment in Canada was with the Falconbridge Nickel Mines, Ltd., has now taken up an appointment with the British Columbia Research Council at the University of British Columbia, Vancouver.

Obituary

SIR PAUL GUETERBOCK, K.C.B.

WE regret to record the death on March 8th of Col. Sir Paul Gueterbock, K.C.B., D.S.O. Sir Paul, who was 67, was a Past President of the Institute of Metals and Managing Director of Capper Pass & Sons, Ltd., of Bristol. He was educated at Rugby and Trinity College, Cambridge, and entered the non-ferrous metals industry in 1908. Prior to World War I, he was mainly concerned with researches into the alloys of lead and tin. Following distinguished war service, in which he was awarded the M.C. and the D.S.O., Sir Paul resumed his work in the non-ferrous industry and was for some time Head of the Research Department of Capper Pass & Sons, Ltd. Subsequently he became Managing Director, an office which he continued to occupy till the time of his death. In addition to his active interest in the work of the Institute of Metals, Sir Paul was a Member of Council of the Institution of Mining and Metallurgy and a Past Chairman of the British Non-Ferrous Smelters' Association.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

Electric " Bunsen " Burner

An adaptable piece of equipment for the laboratory is the new Bunray electric Bunsen burner. This infra-red reflex burner, which can be used in any position, vertically, horizontally or upside-down, combines the advantages of the time-honoured Bunsen burner (instantaneous heat, independence of shape and size of vessel, wide scope of application) with the good features of electrical heating. The Bunray is 6¼ in. high, with a heavy cast iron base which carries on short insulators the socket into which a 340 watt heating element is plugged. This element is protected against spilling or boiling over by a close-fitting, easily-removable quartz sleeve. The horizontal radiation from the vertically mounted tubular heating element is concentrated at a point directly above the burner by reflection from the polished, anodised aluminium cowling acting as a parabolic mirror : this results in the utilisation of almost 90% of the total radiation. The aluminium cowling is provided with a removable lid to facilitate cleaning and withdrawal of the heating element. The heating-up period is only about 1 minute, and temperatures up to 800° C. can be reached. The heat supply can be adjusted by means of a sliding rheostat, or an auto-transformer, or an energy regulator. The Bunray is particularly efficient when heating liquids in glass containers, since normal glass transmits a very high percentage of infra-red. The burner acts, therefore, directly on the liquid to be heated or boiled. This is borne out by the fact that the Bunray cannot be used for bending or blowing glass, as the radiated heat passes through it without heating it.

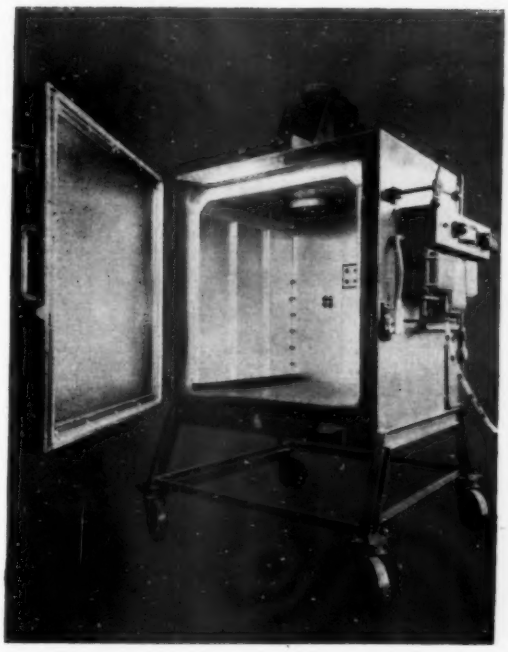
With a number of small accessories, the usefulness of the Bunray can be extended beyond that of an ordinary gas bunsen burner. A hot plate attachment consisting of a cast and machined aluminium plate of 4 in. diameter can be fitted directly into the burner top, and the burner can be converted into a furnace by the use of a crucible attachment. The Bunray is also suitable for use as an infra-red lamp for evaporating liquids from watch glasses or planchettes, making it particularly effective in laboratories using radioactive isotopes.

Shandon Scientific Company, 6, Cromwell Place, London, S.W.7.

Laboratory Oven

A recent addition to the range of low temperature ovens made by The General Electric Co., Ltd., is an easily transportable unit intended for laboratory work. It incorporates all the features required to permit checking and controlling movement of components during tests involving long periods of heat treatment.

The oven has a standard double-case construction with ample heat insulation, and a full length door at the front. Forced air circulation is provided by a centrifugal fan mounted in the roof and driven by an induction motor. Sheathed wire elements are mounted on the side walls behind metal shields which protect the charge from direct radiation, and at the same time form part of the circulation system.



The oven has a volumetric capacity of 3 cu. ft. and is rated at 9 kW. Its temperature is controlled by an expansion thermostat, and the oven is provided with temperature indicating and recording instruments, door switch, and pilot lamps. Maximum operating temperature is 350° C., and through connections are provided at the rear of the oven for external and internal connections to thermo-couples for checking charge temperatures.

The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

New Grades of Nickel for Electronic Uses

Wrought commercially pure nickel and special manganese-nickel alloys are widely used for electrodes and other parts of valves for radio and television, in transmitting valves and in the special types of valves developed for radar. Loosely known as " pure " nickel, there are, in fact, many grades available, where special physical properties have been developed by variations in production technique, or by relatively small additions of other elements. Two new grades of nickel have recently been announced by Henry Wiggin and Co. Ltd.

H.P.A. Nickel is a very pure grade with a minimum nickel content of 99·5%, available in the form of strip, tape and wire. It is specially recommended for components of valves operating at high temperatures where the evaporation of volatile elements such as magnesium cannot be tolerated. It is also useful for cathodes of valves which must have a very long life while delivering only low emission current.

H.P.B. Nickel is intended primarily as a material for cathodes where the sublimation of magnesium cannot be tolerated, due to very small inter-electrode distances, or where the operating temperature of the cathode is higher than usual and leads to excessive evaporation of magnesium from the cathode. The high silicon content of H.P.B. Nickel ensures ready activation and good emission. Care must, however, be exercised in the running of valves with this material, since the high silicon content can result in the build-up of high interface impedances between the cathode sleeve and the coating material under certain conditions.

The compositions of H.P.A. and H.P.B. nickel are given below :—

	H.P.A.	H.P.B.
C %	0·10 max.	0·10 max.
Cu %	0·04 max.	0·04 max.
Fe %	0·05 max.	0·05–1·0
Mn %	0·02 max.	0·10 max.
Mg %	0·01 max.	0·01 max.
Si %	0·03 max.	0·15–0·25
Al %	0·01–0·05	0·02 max.
S %	0·005 max.	0·005 max.
Ni + Co %	99·5 min.	99·5 min.

Henry Wiggin and Co. Ltd., Wiggin Street, Birmingham, 16.

Obstruction Light

FREQUENT maintenance checks are rarely practicable where obstruction lights are fitted on tall chimneys and buildings near airports, and The General Electric Co., Ltd., has introduced a new fitting to help solve this problem. The fitting is the ZA754 quadruple obstruction light, housing four 100-watt Osram G.L.S. lamps in aviation red glass domes with weatherproof sealing rings. The lamps can be underrun to approximately 80% of their rated voltage. Usually one lamp in each of the four units or lights is in circuit at a time, and the others can be switched in when lamp failure occurs. The light can, therefore, be used for a long time before re-lamping is needed.

Body castings are of bronze or Delta bronze, since corrosion is a major problem with such installations ; alternative castings can be supplied to special order. Cast gun-metal mounting brackets are available. Supply to the unit is given through a multi-core cable controlled by a rotary switch from a step-down transformer. This unit is now being used for warning systems on many British power stations.

The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.

Percentage Elongation Tablet

ONE of the most commonly specified mechanical properties of steel is the percentage elongation, as found by a tensile test of the material. Unfortunately it is frequently incompletely specified so that anomalous differences exist between the values required by different standards, and the severity of the requirements of a particular standard may vary with the test piece used.

For a given carbon, or low-alloy molybdenum or chrome-molybdenum steel having a tensile strength in the range of from 20 to 40 tons/sq. in., the percentage elongation will be the same, when determined from cylindrical or rectangular test pieces of any normal dimensions, provided that for each the gauge length L bears a constant ratio to the square root of the cross-sectional area A. This ratio is generally 4, where used in British Standards, that is $L = 4\sqrt{A}$

On this basis the recent revised edition of B.S. 806 specifies all percentage elongations as measured on a gauge length equal to $4\sqrt{A}$, thus making them directly comparable. This presents no difficulty for circular test pieces machined all over. For rectangular test pieces, such as those from plates, it is necessary for economy in testing to standardise a few lengths and widths, letting the cross-sectional area vary with the thickness. The percentage elongations so determined are not directly comparable, even with each other. It is, therefore, necessary to convert them into the equivalent values which would have been found on a gauge length of $4\sqrt{A}$, when all the results are directly comparable.

Provision for this has now been made in B.S. 806 : 1954, Appendix D, which is based on the analysis of many experimental results. The contents of that appendix are summarised on an ivorine card recently issued by Stewarts and Lloyds, Ltd. It is hoped that by facilitating the conversion of test results to a rational basis, and so making them comparable, it will help to rationalise the specifying of percentage elongations in this country.

Kodak DX 80 Developer

A HIGH-CONTRAST liquid developer, DX 80, combining the qualities of long-life, convenience, economy and reliability, is announced by Kodak Ltd. It is primarily intended for processing all types of X-ray films, fluorographic films and cardiographic materials, but it can also be used with equal success in clinical, aerial, infra-red and general industrial photography, and for oscillograph recording work.

The advantages of liquid developers are now widely appreciated. They are convenient to make up ; there is no fear of chemical dust contaminating the darkroom, and they save the time of assistants who are freed for more essential work. DX 80 is claimed to be the most highly concentrated X-ray liquid developer on the British market to-day.

Kodak DX 80 Developer is available in easily-handled 1-gallon bottles. When it is diluted in the recommended proportion of 1 + 4 it will make five gallons of working solution—an ideal quantity for most X-ray darkroom requirements. Four minutes at 68° F. (20° C.) is the recommended development time for X-ray films with this developer, but this time may be extended if additional emulsion speed is required, without the production of an over-contrasty radiograph, and with very little build-up in fog.

A feature of the developer is its keeping quality ; severe tests have shown that it gives uniform film speed and contrast over an unusually long working life. It has been specially compounded so that there is no crystallisation even if the solution is kept at a comparatively low temperature, and throughout its working life the developer remains remarkably free from sludge. An anti-fog agent is incorporated in it. In addition to normal use, the developer is suitable for processing in the tropics (when an anti-swelling agent should be added). The effective working life of the developer can be greatly increased by the addition of Kodak DX 80R Replenisher, which also dilutes 1 + 4 for use.

Kodak Ltd., Harrow, Middlesex.

CURRENT LITERATURE

Book Notices

CERAMICS

A Symposium published by the British Ceramic Society to mark its Golden Jubilee. 870 pp., numerous illustrations. 45s. to members, 65s. to non-members.

THE refractories section of the ceramic industries has always been dependent upon the metallurgical industries. The melting and heat treatment of metals, particularly of iron and steel, provides the chief market for refractories. During recent years there has been a common sphere of research for ceramists and metallurgists in the ceramic-metal mixtures and the carbides. The word 'cermets' indicates a new link.

Metallurgists were interested, therefore, in the decision of the British Ceramic Society during its Jubilee year of 1950, to publish a Symposium on Ceramics. The book has appeared recently. In a foreword, the President of the Society, Dr. A. T. Green, who is also the Director of the British Ceramic Research Association, writes that the book is intended to survey the growth of the practice, the technology and the basic science of ceramics. Thirty scientists contribute, and 200 pages are devoted to basic science and 300 pages to refractories. The remainder of the 870 pages is devoted to pottery and building materials. There is much evidence of scientific progress in the refractories industry and users will welcome this.

The chapters by Dr. G. W. Brindley and Dr. D. M. C. MacEwan on the structural aspects of the mineralogy of clays and related silicates will be interesting to metallurgists. There are a number of diagrams to illustrate the explanations of basic atomic groupings. H. M. Richardson, in a chapter on X-rays and ceramics explains how clay minerals have been classified into three groups, kaolinite, montmorillonite and illite. Dr. J. F. Hyslop writes on dehydration, recrystallisation and vitrification, showing how the heat treatment of clays culminates in the production of crystals and glass.

Chapters of special interest to the iron and steel industry include one by Dr. J. H. Chesters on progress in refractories for steel melting, and one by J. Mackenzie on blast furnace refractories. These two writers deal with the increased use of basic refractories, the development of the silica brick of low flux content and high bulk density, and the introduction of carbon for blast furnace hearths. They include some excellent photographs.

Users of fireclay and alumina refractories will be interested chiefly in the chapter by F. H. Clews. He describes the present methods of examining and testing refractories, including X-ray diffraction photographs, differential thermal analysis, microscopy and electron microscopy. Continuing from the familiar silica-alumina diagram by Bowen and Greig, he explains the development of mullite in aluminous refractories by high temperature kilning, and also the recognition of the cordierite mineral in refractories of low thermal expansion and high spalling resistance. His review of manufacturing processes, and his comments on the importance of de-airing will be interesting to both manufacturers and users.

Dr. W. A. Archibald and E. J. D. Smith apply the description 'super-refractories' to the pure oxides, alumina, magnesia, zirconia, thoria and beryllia. They include many of the carbides, sulphides, silicides and borides as potential high temperature refractories. Their chapter describes preparation of materials, shaping by pressing, tamping, extrusion and slip casting, and also the high temperature kilning of this special ware. Pointing out that at high temperatures of operation the gaseous, liquid or solid environment of a refractory is extremely important, they add that an atmosphere will reduce a particular oxide only if its oxygen potential is lower than the oxygen potential of the oxide.

A chapter of interest to those concerned with fuel economy is by H. Oliver on insulating brick. Reviewing the fifty years of the history of the Society, he points out the change of emphasis from insulation merely to avoid heat wastage through furnace walls, towards low heat capacity of refractories. He discusses principles of heat insulation, the scope of diatomaceous materials, the methods of securing porosity in the alumino-silicate types of refractory insulating brick, and the fundamental research which has been done during the last twenty years.

Certainly the symposium, as a review of fifty years of progress in refractories, has some omissions. The lack of a chapter on crucibles and other refractories for the non-ferrous metals industry is surprising. There has been a great increase in rammings, castables and jointings and a chapter on these materials would be helpful. Refractories for the glass industry are also omitted and there have been a number of interesting developments in this field. The book is an interesting story of progress, however: it will encourage sound technical service by manufacturers of refractories, and it will be a useful book of reference for the discriminating user.

BULBED AND LIPPED STRUCTURAL ALUMINIUM ALLOY SECTIONS (ANGLES AND CHANNELS)

Addendum to Application Brochure No. 6. Aluminium Development Association, Grosvenor Street, London, W.1.

ALUMINIUM DEVELOPMENT ASSOCIATION Applications Brochure No. 6 "The Use of Aluminium Alloys in Structural Engineering," which first appeared in 1950 is an introductory survey to the subject designed to make known the characteristics and uses of aluminium to a fairly wide audience. An important characteristic of aluminium in the field of structural engineering is the facility with which structural sections can be produced by the extrusion process and a range of standard sections was published in B.S.1161 "Aluminium and Aluminium Alloy Sections." An addendum to Brochure No. 6 has just been published—"Bulbed and Lipped Structural Aluminium Alloy Sections (Angles and Channels)"—as a result of recent researches and the development of a range of new shapes to overcome certain problems inherent in their sections. Three sets of data are shown covering equal bulb angles, unequal bulb angles, and lipped channel sections. The publication concludes with some brief notes on the design data, including a comparison between the recommended strut curve for a channel section with the usual Perry curve for the same material.

FULLY SUPPORTED ALUMINIUM ROOF COVERING

Applications Brochure No. 9. 32 pp., numerous illustrations. Paper covers. London, 1953. The Aluminium Development Association, 33, Grosvenor Street, W.1. 2s. 6d.

THIS new A.D.A. publication sets out recommendations as required by the practising plumber and builder on the installation of aluminium for fully supported roof covering. It is likely also to be found helpful by architects and designers in taking into account the properties of the materials used, and certain other factors that affect roof design.

The first section of the brochure describes briefly the appropriate materials in relation to British Standards 1470, 1475 and 1476, applying to sheet and strip, wire and bars, rods and sections. The second section covers such design considerations as the durability of aluminium and the simple procedure to be adopted when it is in contact with other materials; this is followed by an outline of the principal systems of roof covering, with notes on special features.

The subject of work on site occupies the greater part of the brochure, and the text relates to a general layout drawing of a roof, with the various components indicated, and to other illustrations of detail. The stages of forming a standing seam, a conical and a square roll are shown in detail.

The publication contains many photographs of aluminium roofing installations, and a list of allowances and dimensions. Appendices cover definitions of terms; tensile strength of recommended materials; physical properties of pure aluminium, and tables of standard dimensions and weights.

Trade Publications

SITUATIONS occasionally arise where corrosion conditions in the bore of a tube are different from those outside, and one material cannot be found to resist both. In such circumstances, composite tubing may provide the answer. This type of tubing may also be used where a tube is required combining maximum corrosion-resisting properties in the bore with high mechanical strength, as may be the case in high pressure chemical plant. Again, when an expensive material is used for the main purpose of the tube, a saving can be effected by using a lining of a cheaper material such as mild steel. Several combinations of different metals, and of metals with plastics and glass, have been made by Accles & Pollock, Ltd., Oldbury, Birmingham, who have recently issued a booklet on the subject with text in English and French.

IN a recent leaflet illustrated in 3D, Armstrong-Whitworth Metal Industries, Ltd., refer to a number of developments of the Engineering Department which may be regarded as important contributions to British engineering. They include the Bieir infinitely-variable gear, multi-coloured rotogravure printing presses and Kue-Ken jaw and gyratory crushers. Reference is also made to the quality steel castings made by Jarrow Metal Industries, Ltd.

THE latest edition of the Baty Measuring Instruments Catalogue includes a number of new models of dial gauges and related equipment. Apart from straightforward dial gauges, details are given of dial test indicator sets; dial depth gauges; a device for the rapid and accurate inspection of angles; an internal recess gauge; small bore and cylinder gauges; dial micrometers; and bench gauges and comparators. Of particular interest are the Lindley extensometers which are capable of accurately measuring extensions to ± 1/20,000 in. Copies may be obtained from J. E. Baty & Co. Ltd., 39, Victoria Street, London, S.W.1.

INFORMATION Sheet No. 16, recently issued by Foundry Services, Ltd., Nechells, Birmingham, 7, is concerned with aluminium silicon casting alloys, particularly B.S. 1490–LM6. Following an introductory section detailing the properties of this material in the sand and chill-cast conditions, the melting, casting and moulding techniques are discussed. An important feature of this alloy is the change in structure which can be achieved by adding sodium or sodium salts to the molten alloy. This process is known as modification, and its effect is to increase the tensile strength by some 4 tons/sq.in. (e.g. from 7 to 11·5 tons/sq.in. in the case of the sand cast alloy), with even more marked improvement in ductility and toughness. Details are given of the way in which Foseco products can be utilised in carrying out the modification procedure.

WE have received from Deloro Stellite, Ltd., Shirley, Birmingham, a copy of their new publication "Machining with Stellite." It deals comprehensively with all forms of machining, and complete tables of feeds and speeds show how many advantages Stellite cutting tools have over the ordinary cutting tools. Stellite is used in the form of solid cast tool bits, tips, parting blades, milling blades and tipped tools, and details are given of the standard sizes available. Because of the particular properties of the material, the tool setting and grinding techniques are somewhat different from those for ordinary cutting tools, and useful information is given on these points.

THE October issue of METALLURGIA contained a report of a paper read in Sheffield by Mr. W. B. Wallis, President of the Pittsburgh Lectromelt Furnace Corporation, on American arc furnace practice. The paper dealt with the use of large arc furnaces for making steel, particularly of the plain carbon type, by the single slag process. Reprints of the paper and the ensuing discussion are now available from Birlec, Ltd., Tyburn Road, Birmingham, 24.

OPEN coal, coke or wood fires have, in the past, been used for heating or drying ladles in workshops, but this is prohibited in the Iron and Steel Foundries Regulations which came into operation at the beginning of the year. The Morgan Crucible Co., Ltd. have issued a leaflet drawing attention to the advantages of Salamander pre-fired plumbago ladle liners, whose use would eliminate the need for ladle drying. The liners are available for a range of ladle sizes, from 28 lb. to 15 cwt.

IN a search for a bearing metal to meet the requirements of modern high-power internal combustion engines, investigations centred on the existing range of aluminium alloys. These were not suitable under conditions of boundary lubrication, and further work led to the introduction of the aluminium-tin alloys. Hiduminium 29, the latest High Duty Alloys development in this group, has proved its suitability for main bearings, big end bearings, and camshaft bushes in I.C. engines, and has also been successfully used as bushing in large roll-neck rolling mill bearings. Full details of properties and available forms are given in a recent booklet issued by H.D.A.

METALLURGICAL DIGEST

New Creep Resistant Ferritic Steels

By David D. Howat

TO meet high temperature problems involved in improving the thermal efficiency of gas turbines, design has been focused on the effort to utilise higher gas temperatures with protective air cooling for critical parts of the turbine. As a result, although gas temperatures of 1,375° F. or higher prevail at the turbine entry, the temperature at the rim of the disc can be kept to 1,025–1,100° F. This trend has led to the development of ferritic alloys, particularly for turbine rotors and discs, which are superior in creep strength at 1,100° F. to those austenitic steels originally used in jet development.

The development of ferritic creep resistant steels can be divided into two stages:

(1) The relatively simple steels for use in superheater tubes, and for power generation in general.
(2) The production of steels suitable for use in gas turbines.

In the first group the mechanical properties demanded are stringent, calling for exact and carefully controlled heat treatment. On the other hand the service temperatures are not unduly high—maximum about 1,025° F. at the present time—and scaling resistance is not a major problem. In this group of steels, which includes molybdenum, chromium-molybdenum and molybdenum-vanadium steels, the carbide phase is relatively simple, control of the distribution and rate of precipitation of the carbides being dependent upon the heat treatment.

In the gas turbine field, operating conditions are more severe. The service temperatures are higher and scaling resistance becomes a major factor, and a delicate balance must be struck between creep resistance and scaling resistance. Steels of increasingly complex composition have been proposed. Identification of the precipitating phase become more difficult and the conditions for securing the correct dispersion of the carbide phase and its rate of precipitation become increasingly critical.

Molybdenum and molybdenum-vanadium steels proved a starting point for the development of ferritic steels capable of withstanding the more exacting conditions of the gas turbine. Kirby and Sykes state that, although the molybdenum-vanadium steels have a useful creep strength up to 1,100° F. for short time service in jet engines, for long term service (100,000 hr.) the temperature of operation is limited to 975° F. Further, Glen has recently described the remarkable effects obtained by the introduction of titanium into a molybdenum-vanadium steel. This is brought out strikingly by a comparison. At 1,110° F., and under a stress of 13,400 lb./sq. in., the plain molybdenum steel reaches 0·1% creep strain in 10 hr.; the molybdenum-vanadium-titanium steel takes about 20,000 hr. Under the given conditions, this steel compares favourably with an 18/8 chromium-nickel steel with about 1% columbium.

The principal disadvantage of these simple and relatively cheap ferritic steels is poor scaling resistance. Extensive work is in progress to develop methods of improving scaling resistance, the more promising including the formation of a chromium surface layer by gaseous deposition.

The effects of additions of chromium and tungsten to these molybdenum-vanadium steels has been studied, some of the data obtained being shown in Fig. 1. One of the earliest steels for gas turbine work was the 3% chromium, 0·5% molybdenum, 0·75% vanadium steel. Properties of this steel given by Colbeck and Rait are: good hot strength (see Curve 2 in Fig. 1); high degree of stability under long time heating; reasonable scale resistance up to about 1,100° F. and satisfactory forgeability and machinability.

From *Materials and Methods*, Sept., 1953, pp. 87-90.

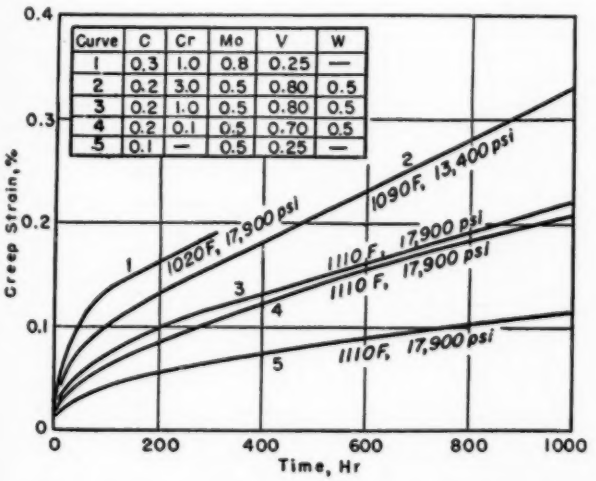
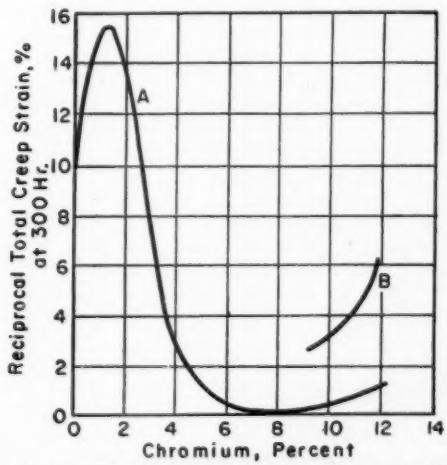


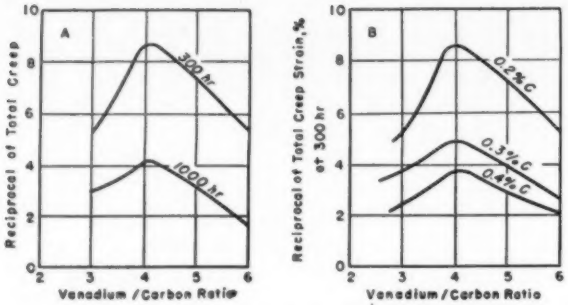
Fig. 1.—Improvement in creep resistance obtained by adding chromium and tungsten to molybdenum-vanadium steels. (Ward and Rait).



A. Base composition 0.2 C, 0.5 Mo, 0.8 V, 0.5% W.

B. Base composition 0.2 C, 0.5 Mo, 0.8 V, 0.15% Cb.

Fig. 2.—Effect of chromium additions on the creep properties. (Colbeck and Rait).



A. Base composition 0.2 C, 3 Cr, 0.5 Mo, 0.5% W.
B. Steel of type 3% Cr, Mo, W, V.

Fig. 3.—Effect of vanadium/carbon ratio on creep properties determined at 17,900 lb./sq. in. and 1,110° F. (Ward and Rait).

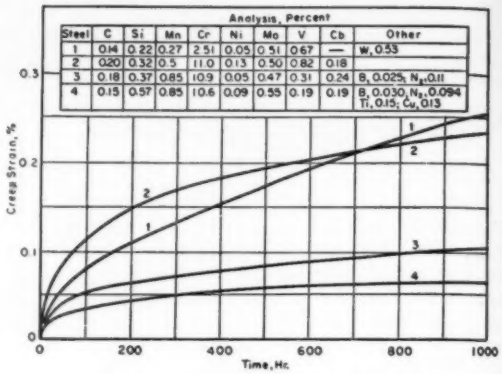


Fig. 4.—Creep properties of complex 12% chromium steels. (Ward and Rait).

The only advantage of increasing the chromium content of these steels is improved scaling resistance. Colbeck and Rait carried out a series of tests showing the effects of variations in content on the creep properties of steels with constant carbon, molybdenum, tungsten and vanadium contents. As shown in Fig. 2, the creep resistant properties pass through a maximum at 1% chromium and then fall rapidly with increase in the chromium content, passing through a minimum at about 8%, and thereafter showing a slight improvement.

Variations in the creep properties with different heat treatments convinced Colbeck and Rait and Ward that the nature and distribution of the carbides in the 1% and 3% chromium-molybdenum-vanadium-tungsten steels are paramount considerations. Various tests on these two steels showed a maximum in creep resistance with a vanadium/carbon ratio of 4 : 1. The results plotted in Fig. 3 also showed that increase in the carbon content above 0·3% adversely affected the creep resistance.

Further work on the 10 and 12% chromium steels has resulted in much improved types being produced for gas turbines. Oliver and Harris have indicated the progressive improvement in creep resistance secured in these newer types of steel. Ward and Rait give further information on the composition and properties of these improved 12% chromium steel. It is shown, for instance, that columbium can be substituted for tungsten with improvement in creep resistance, as indicated in Curve B in Fig. 2, and that creep resistance is considerably improved by high temperature treatment at about 2,275° F.

The addition of boron and titanium to these 12% chromium steels has brought about a considerable improvement in the creep resistance. As shown in Fig. 4, a 12% chromium-molybdenum-vanadium-columbium steel containing 0·03% boron, 0·09% nitrogen and 0·15% titanium, when tested at 1,110° F., under stress of 18,000 lb./sq. in., shows a creep strain of 0·075 in 1,000 hr., or about one quarter of the creep strain shown by a similar steel containing no boron, nitrogen or titanium. The trend also seems to be toward lower vanadium content.

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Titanium Melting Process

THE development of a new titanium melting process, announced recently by Mallory-Sharon Titanium Corporation, Niles, Ohio, is claimed to produce ingots with characteristics superior to those produced by other known processes and, in addition, to increase the yield of metallic titanium from its sponge raw material.

Arc melting and induction melting are the two methods previously used; each has advantages and disadvantages, neither being entirely satisfactory. Arc-melted ingots are not sufficiently homogeneous, while induction-melted ingots have a carbon content that makes them undesirable for many applications.

The advantages of the new process are:—

(1) Ingots are homogeneous and display the same characteristics throughout. Thus, there are no variations in a sheet, for example, rolled from a single ingot. Ingots of a given type are reproducible, and the size and shape can be varied over a wide range.

(2) Carbon content can be controlled exactly to any amount specified, and held as low as the amount inherent in the sponge material. A titanium electrode is used in place of a carbon electrode, and the melting is accomplished in a crucible made of copper, which is water-cooled. Since there is no carbon contamination, machining and welding characteristics are improved and impact strength is increased.

(3) The yield is increased markedly, and more metallic titanium can be produced from a given amount of sponge raw material since scrap loss is reduced. This factor is highly important in view of the high cost of titanium and the scarcity of sponge, now the limiting factor in titanium production.

The new melting process is claimed to be flexible and can be used for a wide variety of alloys. While the bulk of production by the Company is now devoted to commercially-pure light-gauge sheet, hot-rolled by the Company's patented method of rolling, production of the titanium alloy containing 3% aluminium and 5% chromium is being increased.

From *Mechanical Engineering*, October, 1953, p. 814.

LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS

APRIL, 1954 Vol. XLIX, No. 294

Vacuum Equipment Production

Edwards' New Works at Crawley

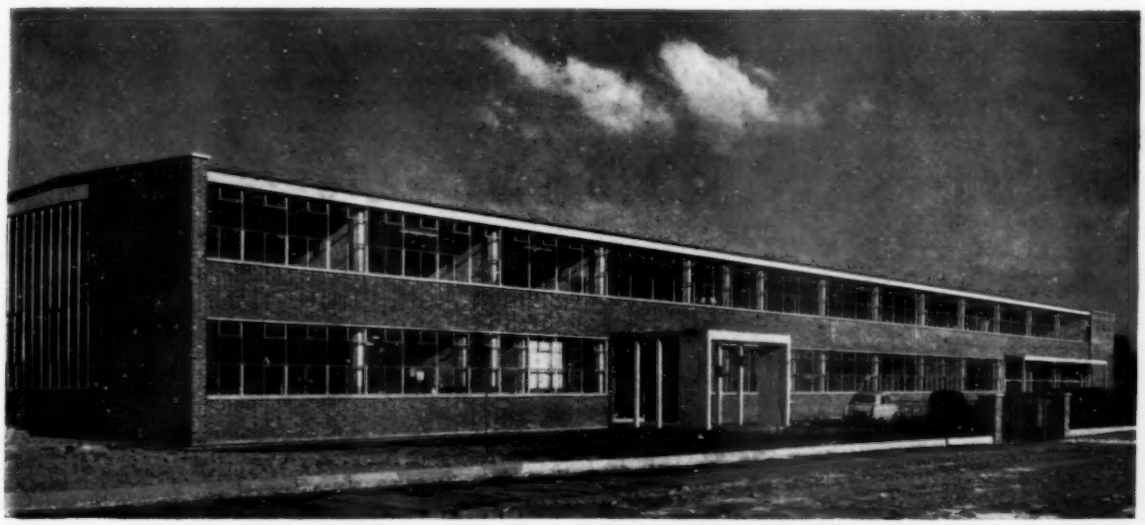
THE recent opening by Sir Ben Lockspeiser, Secretary to the Department of Scientific and Industrial Research, of the new Allendale Works of W. Edwards & Co. (London), Ltd., at Manor Royal, Crawley, Sussex, marked an important stage in the history of the firm, which in thirty-five years has expanded from a one-man business to an enterprise employing a staff of five hundred, and occupying a unique position among scientific and vacuum equipment manufacturers in this country. As Sir Ben remarked: "Great industrial innovations usually demand in these days large sums, both for development and for capital investment, and for this reason modern technology favours the big battalion, but there is a vital and distinctive place for the specialist firm which makes itself highly proficient in its own field, and performs thereby an invaluable service for many industries, and often for research laboratories, also. Messrs. W. Edwards & Co. is an excellent example of such a specialist firm. . . ."

Early History

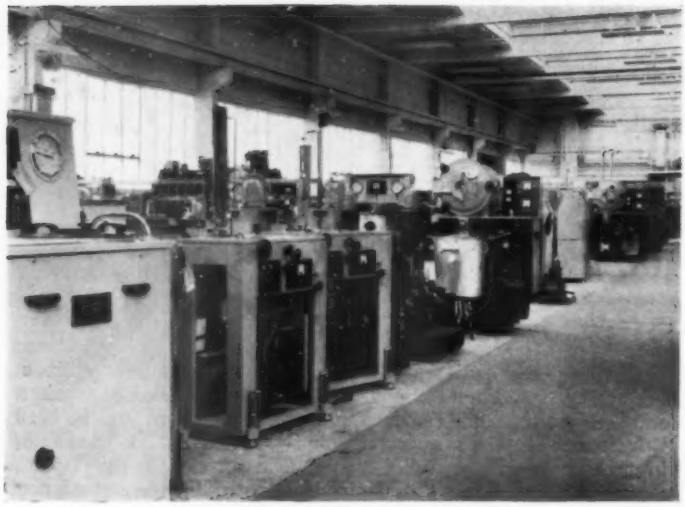
The firm was founded by Frederick D. Edwards, the present Managing Director, who had an unquenchable enthusiasm for science which, via teaching and demonstrating posts at Northampton Polytechnic and the City of London College, crystallised into a specialised interest in discharge phenomena under vacuum conditions. Any redundant apparatus he had remodelled or repaired for this application found a ready market, and in 1919 Mr. Edwards opened his first premises in Allendale Road, near Camberwell Green. Soon afterwards, his father, Mr. W. Edwards, joined in with his own particular interest, the manufacture of laboratory furniture.

Until World War II, the Company actually manufactured little, but acted as factors for vacuum pumps and equipment from America, France and Germany. With the advent of war, the demand for vacuum equipment increased at a phenomenal rate, and Edwards began to manufacture their own pumps and equipment. They had become founder members of a new industry in this country, and rapidly built for themselves a reputation for vacuum "know-how" which has now spread throughout the world via a network of some 45 agents.

Today, Edwards manufacture equipment for every high vacuum application, the range falling naturally into four main groups: means of producing high vacuum; means of measuring, indicating and controlling high vacuum; vacuum systems, apparatus and plant; and accessories. The third group includes standard equipment for the deposition of thin films; scientific instruments such as the electron diffraction camera; and standard and custom-built equipment for specific



The front of the new building at Manor Royal.



View of the plant assembly shop showing some of the products nearing completion.

applications ranging from the determination of gases in metals to a complete exhaust system for television tubes, and to nuclear plant, for which large pumps of very high pumping speeds are involved.

Rapid Expansion

In 1947, a Government representative reported that nowhere had he seen "the degree of congestion that prevailed at Messrs. Edwards factory," adding that the congestion "had to be seen to be appreciated." For the production of the high quality apparatus and plant necessary for high vacuum purposes, it is vitally important for the industrial organisation to have the right atmosphere and facilities to promote efficient manufacture to precision standards. Expansion coinciding with the severe restrictions on building obliged the Company to curtail severely its manufacturing efforts, and imposed an undue strain on the organisation in endeavouring to match production to research and development. The new factory, therefore, provides for the first time most suitable and adequate accommodation for the Company's requirements, both to exploit its research and development plans and to meet world competition.

Negotiations for the move to Crawley commenced in October, 1950, when Lord Wilmot discussed with Sir Thomas Bennett, the Chairman of the Crawley Development Corporation, the possibility of entering the Crawley scheme. Support was received from the Ministry of Supply and Board of Trade, leading to the issue of Industrial Development Certificates. The factory was handed over officially on 1st October, 1953, and most of the employees from the old Sydenham factory have moved to Crawley along with the Company.

The site covers about eleven acres, with a south frontage on Manor Royal and with goods access from Faraday Road on the east. Magpie Wood, facing the Manor Royal entrance, is to remain a permanent feature of the industrial estate. Of the 100,000 sq. ft. of building area, 15,000 are given over to administration, and 85,000 to factory space, including research development, production, stores, boiler house, etc.

Features of the Factory

A feature of most of the general office space is the absence of permanent partition walls. Instead, there is provision for the erection of partitioning as and when necessary to suit changing requirements. The building is heated throughout by hot water at a temperature of about 230° F., forced at high pressure through radiant heat panels suspended from the ceiling, a modern form of heating that has proved extremely effective. The whole building is fitted with tubular fluorescent lighting designed to give adequate shadow-free illumination at bench and machine working height.

The factory area is remarkable for the very small number of upright roof supporting members, thus permitting a clear open floor area. This feature, together with the large area of north light, and the bright, clear decorations, combine to make the factory a very pleasant place to work in. Considerable attention was given to the floors, and the Granolithic floor over the main factory area is worthy of mention, in that the concrete bed was laid in sections with the Granolithic screed applied while the bed was still "green" in order to achieve a monolithic effect.

Research

The Company's commanding position is due in no small measure to the recognition of the vital role of research, since high vacuum technique is rapidly expanding, and fresh applications are continually being found in science, medicine and industry. Without, for example, modern methods of pumping and leak detection to attain and hold high vacuum in very large scale projects, the utilisation of atomic energy and all its implications would be impossible.

Not only is exploratory work undertaken to perfect the firm's products, devise new and more efficient apparatus and keep the company abreast of the latest developments, but a considerable amount of investigatory work must also be done to develop plant and techniques for customer applications—often, work which at first sight may appear to have no connection with high vacuum, e.g., investigation into lacquers as an important complementary to the deposition of thin films in vacuum.

Research investigations include pumps and pumping problems, instruments, vacuum coating, vacuum metallurgy, freeze drying and many other subjects, both from the production and equipment angle, and covering all the manifold applications of the technique. As far as possible in laying out the new factory the laboratories have been kept contiguous to one another as, in practice, work in one section has often been found to influence profoundly the other three. Continuing expansion of the Company's activities, after the plans for the building had been made has necessitated some provisional modifications to this ideal, but it is planned to bring the freeze-drying and allied chemical work into the research area with the building extension now under consideration. The layout of the laboratories is standardised, and no part of the floor area is more than 20 ft. from a grid carrying electricity, gas, cooling water and compressed air supplies, which greatly facilitates re-planning to suit

the various research problems as they arise. Writing and discussion rooms are provided for each section of the laboratory, experience having shown that even for junior members, the laboratory itself is not always the most suitable place for such purposes.

Very necessary to informed research is an efficient library and information service and the Company's reference library is of a very high standard. Part of the service given is the abstraction and circulation to the relevant personnel of details of papers and articles published throughout the world on high vacuum and allied subjects.

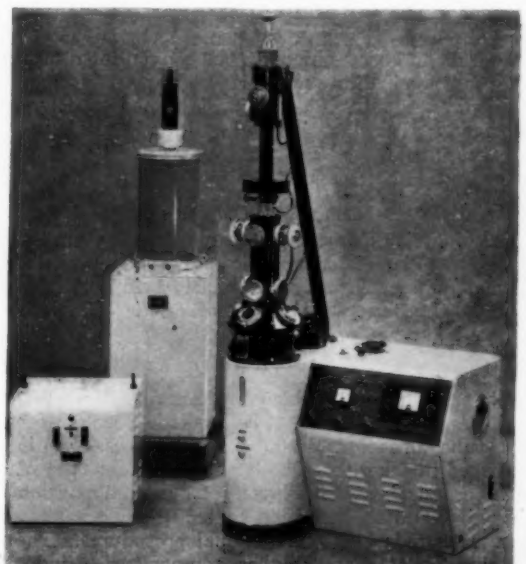
" Vacuum "

The complete abstracting of information on high vacuum by the Company's library staff, mentioned above, was intended for internal circulation. However, high vacuum workers outside the firm began to realise that the Company could be relied upon for elusive references, and requests for copies of the abstracts became frequent.

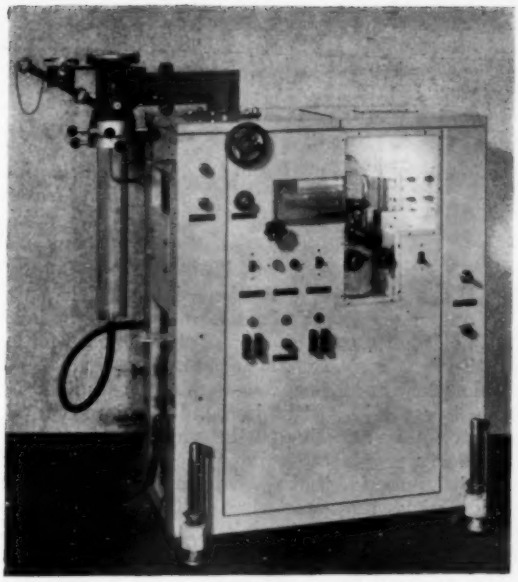
Thus the decision was taken four years ago to start an independent journal *Vacuum*, offering a complete abstracting service together with articles and papers on vacuum work. *Vacuum* is an authoritative scientific journal devoted to the advancement of the technique generally, and as such receives contributions and advertisements from vacuum equipment manufacturers and workers throughout the world. It has been widely accepted as an important and valuable scientific publication.

The Technical Department

In order to ensure that a new project should be passed to production free from ' snags,' the Technical Department was formed, and provides the hub for the firm's technical co-ordination. The Technical Department is a separate entity, possessing its own drawing office and means of production. The department is thus well



The Edwards Finch-type electron diffraction camera with H.T. equipment.



Equipment for the determination of gases in metals installed at B.I.S.R.A.'s Hoyle Street Laboratories.

equipped, not only for taking the original idea from the Research Department and producing a practical piece of apparatus ready to be taken over by the Production Department for quantity production, but also for the design and building of ' custom-built ' plant in ' one-off ' quantities. Segregation of such orders, even if the plant to be built is of considerable size, is of great assistance to the Production Department, which, in general, is organised for quantity manufacture. Under erection at the moment in the Technical Department as pre-production units are a vacuum arc furnace, a continuous coating plant and a coating plant for aluminising 6 ft. diameter astronomical mirrors. A recent ' one-off ' product of Edwards was a freeze-drying plant for the preservation of blood plasma capable of providing the requirements of a population of several million.

Production

The Company's workshops have been specially equipped for precision production of scientific apparatus and equipment. Inspection, including leak detection, plays a dominating part in all stages of fabrication and assembly, so vital is vacuum tightness for the Company's manufactures, and this aspect of the Company's production makes a significant difference from that normally encountered in engineering works.

Machine Shop. The machine shop is well equipped with capstan lathes and milling, grinding and drilling machines, all of post-war construction and modern design. Each type of machine is standardised as to maker in order to simplify maintenance. The grinding machines include some of the latest ' player ' grinders with the refinement of magnetic chucks. The major part of the machine shop is occupied on batch production for rotary vacuum pumps and vapour pumps, although all Edwards machined products are dealt with as required. All machines are jigged and tooled from Edwards, resources, full use being made of the latest types of tools.

Continued on page 208

Analytical Methods for Titanium and Titanium Alloys

By J. A. Corbett*

The sensitivity of titanium and titanium-rich alloys to the presence of impurities makes the determination of impurities at least as important as the determination of intentionally added alloying elements. In this article, the author reviews the methods he has used for both purposes in the case of forged materials.

THERE is little published information on the analysis of titanium and its alloys. Methods have not been standardised, and there is need for more investigation and exchange of information so that reliable procedures can be commonly accepted. The physical properties of titanium and titanium-rich alloys are notoriously sensitive to the presence of impurities, particularly non-metallic impurities. This sensitivity makes it imperative that the determination of impurities should receive the same careful attention as does the determination of alloying elements which are added intentionally.

The following is a review of the methods used by the author for the estimation of impurities in titanium metal, and for the analysis of various binary alloys which have been investigated.

Impurities in Titanium

Thompson[1] has noted the difficulties associated with obtaining a representative sample when preparing sponge titanium for analysis, and has outlined sampling procedures. The composition of powder made from a particular batch of sponge titanium varies considerably with particle size, as shown in Table I.

TABLE I.—ANALYSIS OF POWDERS MADE FROM TITANIUM SPONGE PREPARED BY THE KROLL PROCESS AND SIZED THROUGH B.S.S. SIEVES

Impurity	+ 40 mesh	− 100 + 150 mesh	− 240 mesh
Silicon %	0·01	0·03	0·06
Iron %	0·15	0·13	0·23
Magnesium %	0·40	—	0·29
Carbon %	0·07	0·13	0·20
Nitrogen %	0·05	0·18	0·08

The author has been mainly concerned with the analysis of arc-melted material, and the methods described below have been applied to titanium which has been arc-melted in an argon atmosphere, then forged into rods from which samples of turnings were taken.

Iron.

A colorimetric method employing the iron-thiocyanate reaction is used for the estimation of iron.[2] The metal is dissolved in dilute sulphuric acid, and the solution oxidised with hydrogen peroxide. The solution is then fumed to remove hydrogen peroxide, and after dilution potassium thiocyanate and ammonium persulphate are added. The extinction of the colour is measured in a suitable photo-colorimeter at 4950Å.

Manganese.

The metal is dissolved in dilute sulphuric acid, and the solution oxidised with hydrogen peroxide. After removal of excess hydrogen peroxide by fuming, nitric acid is added and the manganese oxidised with potassium periodate. The permanganate colour is measured at 5200Å.[2]

Aluminium.

The metal is dissolved in 5N hydrochloric acid, and the titanium extracted in a strongly acid solution, using cupferron and chloroform.[3] The aqueous solution is evaporated and adjusted to *p*H 3·5 in a small bulk. The aluminium is then extracted with cupferron and chloroform, the solvent containing the aluminium evaporated, and the residue ignited in a platinum basin. The residue is dissolved in hydrochloric acid and, after addition of aluminol and adjusting to *p*H 5, the colour is measured at 5300Å.

Magnesium.

The aqueous solution from the aluminium extraction contains the magnesium. The solution is evaporated, and the organic material destroyed with sulphuric and nitric acids before precipitating the magnesium with ammonium phosphate. After re-precipitation, the magnesium ammonium phosphate is ignited, and weighed as pyrophosphate.[3] If no aluminium is present, or its estimation is not required, the aluminium extraction stage can be ignored. However, it is advisable to add ammonia to the aqueous solution after the organic material has been destroyed, and to filter any hydroxides which may be precipitated.

Silicon.

The silicon is determined in the conventional manner. After solution in dilute sulphuric acid, and oxidation with hydrogen peroxide, the solution is fumed to dehydrate the silica. After filtration and ignition in platinum, the tared residue is treated with hydrofluoric acid in the usual way.

Chlorine.

Chlorine is determined gravimetrically as silver chloride. The silver chloride is precipitated in the normal manner from the sulphuric acid solution containing titanium. The precipitate is dissolved in ammonia, and re-precipitated.

Carbon.

The method for carbon is similar to the standard methods used for steels. The metal is burnt in oxygen in a tube furnace at 1,200° C., and the carbon dioxide absorbed in askerite. The titanium turnings are placed in a ceramic boat with layers of alundum powder and tin chips, and the liberated carbon dioxide is absorbed and measured using conventional procedures. The use of silica boats, and higher temperatures (induction furnace) has been suggested for carbon contents less than 0·05%.

* Physical Metallurgy Section, C.S.I.R.O., Baillieu Laboratory, University of Melbourne, Victoria, Australia.

Tungsten and Molybdenum.

Toluene dithol is used to extract and separate molybdenum from strongly acid solutions and tungsten from weakly acid solutions.[4] The extracted coloured complexes are measured in a suitable photo-colorimeter. The method has been found suitable for the small amount of tungsten usually present as an impurity.

Nitrogen.

A modified Kjeldahl method is used, and various acid mixtures have been suggested for dissolving the metal without loss of nitrogen due to vigorous action. The author, in agreement with Thompson,[1] has found with tests on titanium nitride, and additions of ammonium sulphate, that the normal digestion in sulphuric acid and hydrogen peroxide with vigorous fuming gives complete conversion to ammonium sulphate.

The acid solution of the metal is treated with sodium hydroxide, and is distilled in the usual manner. The distillate is received in a standard acid solution, and the excess acid is titrated with standard sodium hydroxide. The method involving direct Nesslerisation without distillation[5] has also been used with success.

Oxygen.

The vacuum fusion methods which are used for the estimation of oxygen in steels and other metals can be applied to titanium.[6,7] Temperatures of 1,800–1,900° C. are used, and the metal is melted in an iron bath, graphite and tin being used in some methods as accelerators.

The author has found that the chlorination method[8] gives satisfactory results. The metallic constituents are volatilised, leaving a residue of titanium dioxide which is analysed. There is evidence that the presence of some metals may cause low results : tungsten and molybdenum may form oxychlorides which are volatile. The method is simple to control, and has much to recommend it, particularly for the production laboratory.

Titanium Alloys

During the past five years, the author has investigated methods for the analysis of a number of binary alloys of titanium, and in many cases colorimetric methods have proved to be very satisfactory. Numerous colorimetric methods are available for the estimation of various constituents in steels and non-ferrous alloys, and these have proved convenient starting points for the development of colorimetric methods for the analysis of titanium alloys.

Most of the reagents used for forming coloured complexes either do not react with titanium or form colourless compounds. Where alkaline solutions are necessary, the presence of citrate prevents the precipitation of titanium hydroxide. Some procedures require the boiling of acid solutions, and this may cause hydrolysis, but, with careful control of titanium concentration, acid concentration and boiling time, hydrolysis can sometimes be avoided.

Solution of the alloys is effected in dilute sulphuric acid, and the solution is oxidised with hydrogen peroxide. The tetravalent titanium sulphate is colourless, and a sulphate solution is a convenient medium for most of the colour-forming reactions used.

In general, for a limited range of concentrations, colorimetric methods can provide results comparable with, and sometimes better than, ordinary chemical methods. With high concentrations, the accuracy as a percentage of the total content is reduced, and may not be within the desired limits. The maximum percentages noted in the following descriptions of colorimetric methods are those chosen to suit the particular purposes for which the analyses were required. By adjusting weights, and sometimes dilutions, higher percentages can be estimated with a corresponding decrease in absolute accuracy.

Iron.

The colorimetric method, using thiocyanate, outlined in the section on impurities is used for iron contents up to 2%, the accuracy being ± 2%. For higher iron contents, the iron is precipitated as sulphide in an alkaline citrate solution. The iron sulphide is collected and, after solution in hydrochloric acid, the iron is reduced and titrated with a suitable oxidising agent, such as potassium dichromate.

Manganese.

The colorimetric method using potassium periodate is used for manganese contents up to 4% with an accuracy of ± 1%. The volumetric method, involving the use of persulphate and a silver catalyst to oxidise the manganese to permanganate, and subsequent titration with arsenite, has proved applicable for high manganese contents.

Copper.

The dithyl dithiocarbamate coloured complex method used for steels and aluminium alloys,[9] has proved suitable for copper contents up to 4%, the accuracy being ± 1%. The copper is determined by the formation of the dithyl dithiocarbamate coloured complex in an ammoniacal citrate solution. When accurate determinations of high copper contents are required, the copper is precipitated as the sulphide from acid citrate solutions. The precipitated copper is collected and estimated with thiosulphate.

Cobalt.

Nitroso-R-salt is used in a buffered solution to give the coloured cobalt complex.[10] Any interference by iron is prevented by boiling with nitric acid. Titanium present up to 50 mg. per 50 ml. does not precipitate, but if greater amounts of titanium are present, precipitation can be avoided by the addition of sodium citrate. The method is used for cobalt contents up to 4% with an accuracy of ± 1%. For greater cobalt contents, the cobalt is separated as the sulphide in alkaline citrate solution. The cobalt is estimated gravimetrically using α-nitroso β-napthol.

Nickel.

The colorimetric method used for steels[9] is applied to titanium alloys. Dimethylglyoxime is used to form a coloured nickel complex in an alkaline citrate solution. Iodine is added to prevent the precipitation of nickel, and the citrate present prevents the precipitation of titanium. The method has been used to estimate nickel up to 4% with an accuracy of ± 1%. Higher amounts of nickel are estimated by separating the nickel as sulphide in an alkaline citrate solution and precipitating with dimethylglyoxime.

Chromium.

Colorimetric procedures for the estimation of chromium depend upon the oxidation of chromium to dichromic

acid with persulphate and silver nitrate in a boiling acid solution. When large amounts of titanium are present, precipitation occurs causing a turbidity which interferes with the colour measurement. However, by controlling the titanium concentration (50 ml. of a 2N sulphuric acid solution containing 50 mg. of titanium) the chromium can be oxidised without titanium precipitating. Under these conditions, the chromium concentration obtained from alloys with less than 2% chromium is too small to measure the colour directly. The diphenyl carbazide colour reaction is used to estimate the small amounts of chromium present.

A method based on the above procedures is used for chromium contents up to 2%, with an accuracy of ± 2%. The final colour measurement is made in 1N sulphuric acid. This is higher than suggested by Sandell,[11] but the results are reproducible if the colour is measured immediately. Interference, due to manganese, if it is present as an impurity, is allowed for by measuring the colour due to permanganate, and correcting the chromium result accordingly.

Volumetric procedures are used for high chromium contents. The chromium is oxidised with persulphate, using silver nitrate as a catalyst, a known excess of ferrous sulphate is then added, and the solution titrated with potassium permanganate.

Tin.

A conventional volumetric procedure is used. The tin is precipitated as sulphide from a hot acid citrate solution. The sulphide is collected and ignited in a nickel crucible. The stannic oxide is then fused with sodium peroxide and, after solution of the melt in hydrochloric acid, the tin is reduced and titrated with iodine.

Tantalum.

Tantalum is estimated by precipitation with tannin.[12] The alloy is dissolved in a platinum basin with hydrofluoric and nitric acids. After the addition of sulphuric acid and subsequent fuming, the mixed oxides are precipitated with ammonia. The oxides are fused with potassium pyrosulphate, and the tantalum is precipitated with tannin in a sulphuric acid solution. The tantalum oxide is fused and re-precipitated, and the final pentoxide precipitate is checked for titanium colorimetrically.

Aluminium.

A cupferron-chloroform extraction is made to remove titanium, and the aluminium is estimated gravimetrically with 8-hydroxyquinoline. The alloy is dissolved in dilute hydrochloric acid, and the titanium is removed by precipitating with cupferron, and extracting with chloroform. The aqueous solution is evaporated and the organic material destroyed with sulphuric acid and nitric acid. Aluminium is precipitated with 8-hydroxyquinoline in the conventional manner, and the aluminium complex is dried and weighed.

Silver.

Silver contents less than 1% are estimated by precipitation of the silver as chloride in the presence of titanium. The precipitate is dissolved in ammonia and re-precipitated.

When present in large amounts, the silver is separated by precipitation as the sulphide, after solution of the alloys in nitric and hydrofluoric acids. The sulphides are dissolved in nitric acid, and the silver precipitated with hydrochloric acid.

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Vacuum Equipment Production

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Sheet Metal and Welding Section. The sheet metal section is well equipped with hand and power guillotines as well as bending and folding machines. The welding section is equipped for gas and electric welding. Leak detection enters its most active and important phase in this section, but good design and properly skilled workers demonstrate that leak-tight welds can be obtained as routine.

Assembly. A large assembly bay spanned by a three-ton travelling crane is used for the erection of all large plant, in particular standard vacuum coating and freeze-drying models. Elsewhere there is a rotary and vapour pump assembly section. Once more, inspection plays a vital part, and in the case of rotary pumps each pump is run for 96 hours. At the end of this period the pump is tested with regard to performance, i.e., ultimate vacuum obtainable and capacity, before being put into stock.

Sales

The selling of high vacuum equipment involves personnel and procedure specially trained and organised to give consultory and advisory service, and hence staff must have a considerable technical knowledge; the application of high vacuum is such a new technique that fresh problems are continually arising for study and research and development action. Very close contact is maintained between research and sales staff, and the company's policy is to encourage the Sales to call upon research personnel to accompany them on visits and study customers' problems. This promotes that personal contact with the customer that has always been the principle of the founders of the firm, besides bringing research personnel into more intimate contact with the customers' practical problems.

Export plays a large part in the Company's sales and in addition to W. Edwards & Co. (Canada), Ltd., engaged in the sale and in some cases the assembly of the Company's products in the dollar area, some forty-five agents are distributed all over the world, each having one or more experts who have been trained in the Company's factory.